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ANNALS

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VOLUME II.

I.—*Application of Organic Acids to the Examination of Minerals.*

[Second Paper.]

BY H. CARRINGTON BOLTON, PH. D.

Read January 5th, 1880.

26. The behavior of minerals with organic acids has already formed the subject-matter of two papers read before the Academy in 1877 and 1878, and we now present the results of a continuation of our researches.

In our first paper* we described several new methods of attacking minerals, and their application to ninety-five specimens; in the following pages we extend the investigation to one hundred and six additional minerals. These methods of decomposition were as follows :—

1st. Treatment with a cold saturated solution of citric acid.
2d. Treatment with a boiling solution of the same.
3d. Heating with a saturated solution of citric acid to which sodium nitrate is added.
4th. Heating with a saturated solution of citric acid to which ammonium fluoride is added.

And in a second paper, under another title,† we added a fifth reaction :—

5th. Heating with a concentrated solution of citric acid to which potassium iodide is added.

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* Annals N. Y. Acad. Sci., Vol. I, p. 1.

† Behavior of Natural Sulphides with Iodine and other Reagents. Annals N. Y. Acad. Sci., Vol. I, p. 153.

Similar reactions with oxalic, tartaric, acetic, and other organic acids, were described in the first paper, but preference is given to citric acid on account of its greater solvent power.

Minerals belonging to several groups were submitted to these processes, and gave phenomena which may be summarized as follows:

1st. More or less complete decomposition and solution of oxides, phosphates, etc., without formation of precipitates or liberation of gases.

2d. Complete solution of carbonates with evolution of carbonic anhydride.

3d. Decomposition of sulphides with evolution of sulphuretted hydrogen.

4th. Decomposition of sulphides with oxidation of the sulphur.

5th. More or less perfect decomposition of silicates with separation of either slimy or gelatinous silica.

6th. Decomposition of certain species by reagents forming characteristic precipitates.

7th. Wholly negative action.

These facts demonstrated that citric acid has a power of decomposing minerals little less than that possessed by hydrochloric acid, and that this very difference in degree gives the organic acid an advantage over the mineral acid in the determination of species.

27. This peculiar selective power of citric acid rendered desirable a further study of its action on a larger number of minerals; the following list contains the names of the species which have since been submitted to the process named, together with their formulæ, condition, and locality.

Within the groups,—I, Sulphides, Arsenides, Tellurides, etc., —II, Oxides,—III, Silicates, and—IV, Sundries, the minerals are arranged in the order in which they are given in Dana's System of Mineralogy.

We desire to express our thanks to Prof. Thomas Egleston, of the School of Mines, Columbia College, who has again placed us under obligations by supplying many of the rarer minerals.

I. SULPHIDES, ARSENIDES, Etc.

Mineral.	Formula.	Description.	Locality.
Sulphur.............	S_2	massive	Humboldt, Nev.
Realgar.............	$As\ S$	crystalline............	Hungary.
Orpiment	$As_2\ S_3$	crystals	Hungary.
Bismuthinite........	$Bi_2\ S_3$	in quartz..............	Clear Creek, Col.
Domeykite..........	$\cancel{Cu}_3\ As_2$	massive	Chili, S. A.
Clausthalite..........	$Pb\ Se$	———	Tilkerode, Hartz.
Alabandite..........	$Mn\ S$	crystalline............	Mexico.
Hessite..............	$Ag\ Te$	———	Boulder, Col.
Tiemannite..........	$Hg\ Se$	incrusting.............	Clausthal, Hartz.
Millerite	$Ni\ S$	crystalline............	Lancaster Co., Pa.
Linnaeite	$2\ Co\ S + Co\ S_2$	crystals...............	Müsen, Prussia.
Cobaltite............	$Co\ (S,\ As)_2$	grains	Tunaberg, Sweden.
Leucopyrite.........	$Fe\ As_2$	massive	Breitenbrunn, Saxony.
Nagyagite...........	$2\ (Pb,\ Au) + 3\ (Te,\ Sb,\ S.)$	foliated	Austria.
Covellite............	$\cancel{Cu}\ S_2$	massive	Germany.
Berthierite	$Fe\ S + Sb_2\ S_3$	crystalline............	Braunsdorff, Saxony.
Jamesonite..........	$2\ (Pb,\ Fe)\ S + Sb_2\ S_3$	fibrous................	———
Pyrargyrite..........	$3\ Ag\ S + Sb_2\ S_3$	massive...............	Chili.
Proustite...........	$3\ Ag\ S + As_2\ S_3$	massive	Chili.

Boulangerite	$3\,Pb\,S + Sb_2\,S_3$	massive	———
Tennantite	$4\,(\cancel{Cu}\,Fe)\,S + As_2\,S_3$	crystalline	Cornwall, England.
Stephanite	$5\,Ag\,S + Sb_2\,S_3$	massive	Mexico.
Polybasite	$9\,(Ag\,\cancel{Cu})\,S + (Sb, As)_2\,S_3$	massive	———
Enargite	$3\,\cancel{Cu}S + As_2\,S_5$	massive	Gilpin Co., Colorado.
Kermesite	$2\,Sb\,S_3 + Sb\,O_3$	crystalline	Braunsdorff, Saxony.

II. OXIDES.

Mineral.	Formula.	Description.	Locality.
Melaconite	$Cu\,O$	massive	Copper Harbor, L. S.
Corundum	$Al_2\,O_3$	white, massive	North Carolina.
Menaccanite	$(Ti, Fe)_2\,O_3$	crystals	Ilmen Mts., Russia.
Washingtonite	$(Ti, Fe)_2\,O_3$	crystals	Litchfield, Conn.
Spinel	$\dot{Mg}\,\dddot{\cancel{Al}}$	crystals	Franklin, N. J.
Chrysoberyl	$\dot{Be}\,\dddot{\cancel{Al}}$	crystals	Brazil.
Cassiterite	$\ddot{Sn}$	crystals	Cornwall, England.
Rutile	$\ddot{Ti}$	crystals	York, Pa.
Braunite	$2\,\dot{Mn}_2\,\ddot{Mn} + \dot{Mn}\,\ddot{Si}$	crystalline	Thuringia.
Goethite	$\dddot{\cancel{Fe}}\,\dot{H}$	crystalline	Easton, Pa.
Gummite	$(\dddot{\cancel{U}}\,\dddot{\cancel{Fe}}) + \dot{H}_3$	amorphous	North Carolina.

Quartz	$\ddot{Si}$	crystals	Conn.
Hyalite	$\ddot{Si} + aq.$	mammillary	Waltsch, Bohemia.

III. SILICATES.

Mineral	Formula.	Description.	Locality.
Enstatite	$\dot{Mg}\,\ddot{Si}$	massive	North Carolina.
Hypersthene	$(\dot{Mg}\,\dot{Fe})\,\ddot{Si}$	massive	Labrador.
Petalite	$(\frac{1}{5}\dot{R}_3 + \frac{4}{5}\dddot{\bar{R}})\,\ddot{Si}_3 + 3\,\ddot{Si}$	massive	Sweden.
Pargasite	$(\dot{R}_3\,\dddot{\bar{R}})\,(\ddot{Si}\,\dddot{\bar{Al}}\frac{2}{3})$	massive	Diana, N. Y.
Actinolite	$(\dot{Ca}\,\dot{Mg}\,\dot{Fe})\,\ddot{Si}$	crystals	Oxbow, N. Y.
Asbestus	$(\dot{R}_3\,\dddot{\bar{R}})\,(\ddot{Si}\,\dddot{\bar{Al}}\frac{2}{3})$	silky fibrous	———
Beryl	$(\frac{1}{2}\dot{Be}_3 + \dddot{\bar{Al}}\frac{1}{2})\,\ddot{Si}_3$	transp. crystals	Brazil.
Tephroite	$\dot{Mn}_2\,\ddot{Si}$	massive	Franklin, N. J.
Pyrope	$(\frac{1}{2}(\dot{Mg}, \dot{Ca}, \dot{Fe}, \dot{Mn})_3 + \frac{1}{2}\dddot{\bar{Al}})_2\,\ddot{Si}_3$	crystals	Bohemia.
Colophonite	$(\frac{1}{2}\dot{R}_3 + \frac{1}{2}\dddot{\bar{R}})_2\,\ddot{Si}_3$	crystals	Willsborough, N. Y.
Zircon	$\ddot{Zr}\,\ddot{Si}$	crystals	North Carolina.
Vesuvianite	$(\frac{3}{5}\dot{R}_3 + \frac{2}{5}\dddot{\bar{R}})\,\ddot{Si}_3$	crystals	Moldavia.
Allanite	$\ddot{Si}, \dddot{\bar{Al}}, \dot{Fe}, \dot{Mn}, \dot{Ce}, \dot{La}, \dot{Dd}, \dot{Y}.\,\dot{H}$	partially decomposed	Virginia.
Zoisite	$(\frac{1}{3}\dot{Ca}_3 + \frac{2}{3}\dddot{\bar{Al}})_2\,\ddot{Si}_3$	massive	Conway, Mass.
Ilvaite	$(\frac{3}{5}\dot{R}^3 + \frac{2}{5}\dddot{\bar{R}})\,\ddot{Si}_3$	massive	Hartz Mts.

Iolite	$\ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}. \dot{\mathrm{Fe}}, \dot{\mathrm{Mg}}$	translucent	Finland.
Phlogopite	$(\frac{7}{11}\dot{\mathrm{R}}_3 + \frac{4}{11}\dddot{\mathrm{R}})_2\ \ddot{\mathrm{Si}}_3$	micaceous	Montville, N. J.
Lepidolite	$\ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}, \dddot{\mathrm{Fe}}, \dot{\mathrm{Li}}. \dot{\mathrm{K}}, \mathrm{Fl}$	micaceous	Paris, Maine.
Nephelite	$(\frac{1}{4}\dot{\mathrm{R}}_3 + \frac{3}{4}\dddot{\mathrm{Al}})_2\ \ddot{\mathrm{Si}}_3 + \frac{3}{4}\ddot{\mathrm{Si}}$	mixed with biotite	Vesuvius.
Lapis lazuli	$\ddot{\mathrm{Si}}. \dddot{\mathrm{Al}}, \dot{\mathrm{Ca}}, \dot{\mathrm{Na}}, \mathrm{S}.$	massive	Brazil.
Leucite	$\dot{\mathrm{K}}\ \ddot{\mathrm{Si}} + \dddot{\mathrm{Al}}\ \ddot{\mathrm{Si}}_3$	crystals	Vesuvius.
Anorthite	$(\frac{1}{4}\dot{\mathrm{R}}_3 + \frac{3}{4}\dddot{\mathrm{Al}})_2\ \ddot{\mathrm{Si}}_3$	massive	Tunaberg, Sweden.
Oligoclase	$(\frac{1}{4}(\dot{\mathrm{Na}}, \dot{\mathrm{Ca}})_3 + \frac{3}{4}\dddot{\mathrm{Al}})_2\ \ddot{\mathrm{Si}}_3 + 3\frac{3}{4}\ \ddot{\mathrm{Si}}$	massive	Chester Co., Pa.
Andalusite	$\dddot{\mathrm{Al}}\ \ddot{\mathrm{Si}}$	crystals	Bavaria.
Fibrolite	$\dddot{\mathrm{Al}}\ \ddot{\mathrm{Si}}$	crystalline	Wilmington, Del.
Topaz	$\dddot{\mathrm{Al}}\ \ddot{\mathrm{Si}}$	crystals	Brazil.
Titanite	$(\dot{\mathrm{Ca}} + \ddot{\mathrm{Ti}})\ \ddot{\mathrm{Si}}$	crystals	Diana, N. Y.
Staurolite	$(\frac{1}{3}\dot{\mathrm{R}}_3 + \frac{4}{5}\dddot{\mathrm{Al}})_4\ \ddot{\mathrm{Si}}_3$	crystals	Franconia, N. H.
Laumontite	$\ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}, \dot{\mathrm{Ca}}, \dot{\mathrm{H}}$	crystals	Peter's Point, N. S.
Thomsonite	$2\ \ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}\ (\frac{3}{4}\ \dot{\mathrm{Ca}} + \frac{1}{4}\dot{\mathrm{Na}}), 2\frac{1}{2}\dot{\mathrm{H}}$	crystalline	Renfrewshire, Scotland.
Mesolite	$3\ \ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}\ (\frac{2}{3}\dot{\mathrm{Ca}} + \frac{1}{3}\dot{\mathrm{Na}}) + 3\ \dot{\mathrm{H}}$	crystalline	Peter's Point, N. S.
Herschelite	$\ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}, \dot{\mathrm{Ca}}, \dot{\mathrm{Na}}, \dot{\mathrm{K}}, \dot{\mathrm{H}}$	——	Cyclops, Catania.
Heulandite	$6\ \ddot{\mathrm{Si}}, \dddot{\mathrm{Al}}, \dot{\mathrm{Ca}}, 5\dot{\mathrm{H}}$	red, crystalline	Fassathal, Tyrol.
Bowenite	$2\ \dot{\mathrm{Mg}}\ \ddot{\mathrm{Si}} + \dot{\mathrm{Mg}}\ \dot{\mathrm{H}}_2$	amorphous	Smithfield, R. I.
Bastite	——	massive	Germany.
Genthite	$(\frac{2}{3}\ (\dot{\mathrm{Ni}}, \dot{\mathrm{Mg}}) + \frac{1}{3}\dot{\mathrm{H}})_2\ \ddot{\mathrm{Si}} + \frac{4}{3}\dot{\mathrm{H}}$	amorphous	North Carolina.

Kaolin	$\dddot{\bar{Al}}\,\ddot{Si}_2 + 2\dot{H}$	pulverulent	Rossville, Staten Island.
Gieseckite	$\ddot{Si}, \dddot{\bar{Al}}, \dddot{\bar{Fe}}, \dot{Mg}, \dot{Ca}, \dot{Na}, \dot{H}$	massive	St. Lawrence Co., N. Y.
Jefferisite	$(\frac{2}{5}\dot{R}_3 + \frac{3}{5}\dddot{\bar{R}})_2 + \ddot{Si}_3 + 3\dot{H}$	micaceous	West Chester, Pa.
Prochlorite	$(\frac{4}{7}(\dot{Mg}\,\dot{Fe})_3 + \frac{3}{7}\dddot{\bar{Al}})\,\ddot{Si} + \frac{4}{5}\dot{H}$	crystalline	New Bedford, Mass.
Masonite	$(\frac{1}{4}(\dot{Fe}\,\dot{Mg})_3 + \frac{3}{4}\dddot{\bar{Al}})_4\,\ddot{Si}_3 + 3\dot{H}$	massive	Natic, R. I.

IV. SUNDRY MINERALS.

Mineral.	Formula.	Description.	Locality.
Atacamite	$3\,\dot{Cu}\,\dot{H} + Cu\,Cl\,\dot{H}$	granular	Chili.
Columbite	$(\dot{Fe}\,\dot{Mn})\,(\ddot{\ddot{Cb}}\,\ddot{\ddot{Ta}})$	crystalline	Haddam, Conn.
Mimetite	$3\,\dot{Pb}\,\dddot{As} + Pb\,Cl$	crystals	Bohemia.
Triphylite	$(\dot{Fe}\,\dot{Mn}\,\dot{Li})_3\,\dddot{P}$	massive	Grafton, N. H.
Triplite	$\dot{R}_3\,\dddot{P} + R\,Fl$	massive	Limoges, France.
Libethenite	$\dot{Cu}_4\,\dddot{P} + \dot{H}$	crystalline	Cornwall, England.
Olivenite	$\dot{Cu}_3\,(\dddot{As}, \dddot{P}) + \dot{Cu}\,\dot{H}$	crystalline	Cornwall, England.
Pseudomalachite	$\dot{Cu}_6\,\dddot{P} + 3\,\dot{H}$	massive-granular	Copperopolis, Utah.
Wavellite	$\dddot{\bar{Al}}\,\dddot{P}, \dot{H}$	crystalline	Montgomery Co., Ark.
Pharmacosiderite	$3\,\dddot{\bar{Fe}}\,\dddot{As} + \dddot{\bar{Fe}}\,\dot{H}_3 + 12\,\dot{H}$	crystalline	Cornwall, England.

Torbernite............	$\dddot{\bar{U}}_2\,\dddot{\ddot{P}} + \dot{Cu}\,\dot{H} + 7\,\dot{H}$	crystals............ ..	Cornwall, England.
Autunite............	$\dddot{\bar{U}}_2\,\dddot{\ddot{P}} + \dot{Ca}\,\dot{H} + 7\,\dot{H}$	crystals..............	Autun, France.
Ulexite...............	$\ddot{Si}, \dddot{B}, \dot{Ca}, \dot{Na}, \dot{K}, \dot{H}$	nodular fibrous........	Nevada.
Cryptomorphite......	$\dddot{B}, \dot{Ca}, \dot{Na}, \dot{H}$	chalky...............	Oregon.
Wolframite..........	$(\dot{Fe}\,\dot{Mn})\,\dddot{W}$	massive..............	Zinnwald, Bohemia.
Hübnerite	$\dot{Mn}\,\dddot{W}$	massive.............	Nye Co., Nev.
Scheelite.............	$\dot{Ca}\,\dddot{W}$	crystals..............	Zinnwald, Bohemia.
Wulfenite.	$\dot{Pb}\,\dddot{Mo}$	crystals..............	Mies, Carinthia.
Barite	$\dot{Ba}\,\dddot{S}$	massive...	Pillar Point, N. Y.
Celestite.............	$\dot{Sr}\,\dddot{S}$	crystals........... ..	Strontian Is., L. Erie.
Anhydrite...........	$\dot{Ca}\,\dddot{S}$	crystals..	Durremberg.
Crocoite.	$\dot{Pb}\,\dddot{Cr}$	crystalline....	Hungary.
Brochantite..........	$\dot{Cu}\,\dddot{S} + 2\tfrac{1}{2}\,\dot{Cu}\,\dot{H}$	crystalline.....	Chili.
Mercury.	Hg	liquid.........	———
Arsenic..............	As_4	massive..............	Germany.
Graphite	C	foliated.	Ticonderoga, N. Y.
Aragonite	$\dot{Ca}\,\ddot{C}$	crystalline............	N. Y.

One hundred and six species.

28. The minerals of the foregoing list were submitted to the action of the following reagents successively: (1) A solution of citric acid saturated at the temperature of the laboratory, say 65° to 70° Fahrenheit; this we call simply "citric acid." (2) The same solution to which solid sodium (or potassium) nitrate is added, which for convenience we shall call the "nitro-citric mixture" (3) The same solution to which solid potassium iodide is added at the time of testing, and which for simplicity we shall designate as the "iodo-citric mixture."

The action of these reagents was studied in the simple manner detailed in our first paper. The mineral to be examined was carefully freed from its associated gangue and finely pulverized in an agate mortar; a portion was placed in a test-tube, the solution of the acid was added, and the resulting phenomena, in the cold, and on boiling, carefully noted. In many instances the partial decomposition of the mineral was ascertained by filtering from the residue, and testing the solution with an appropriate reagent; or by examining the disengaged gas with a suitable test-paper.

Sulphides, Arsenides, etc.

29. Minerals of this group treated with citric acid alone, yielded results as follows:

(*a*) Clausthalite and leucopyrite dissolve in the cold without liberation of gas.

(*b*) Alabandite is very strongly attacked in the cold, with evolution of sulphuretted hydrogen. On applying heat it is wholly soluble. In this respect alabandite appears to be the most easily decomposed of all the sulphides yet examined, 37 in number.

(*c*) Boulangerite, jamesonite, and kermesite are more or less attacked by boiling citric acid, yielding sulphuretted hydrogen. The remaining minerals of this group resist the action of cold or hot citric acid. Sulphur is absolutely unattacked even when the citric acid solution is heated to the melting point of the element.

The powerful solvent action of a mixture of citric acid and sodium nitrate was discussed in our first paper (19), here we

need only add that the intensity of action claimed for it is fully maintained by later researches.

(*d*) All the minerals of the first group, 25 in number, with three exceptions, dissolve in the nitro-citric mixture rapidly and completely, several of them yielding solutions of characteristic color. Even sulphur itself is decidedly attacked, with formation of sulphuric acid. The exceptions are realgar, orpiment, and proustite.

(*e*) Two of these, realgar and orpiment, are partially decomposed by boiling with the iodo-citric mixture. Proustite and sulphur resist even on prolonged heating. All the remaining minerals of this group are quite readily dissolved, the decomposition of the sulphides being accompanied by liberation of sulphuretted hydrogen.

The differentiating power of these solvents is again exhibited by these reactions. In our first paper we showed, that while bornite and pyrrhotite are decomposed by citric acid, their kindred compounds, chalcopyrite and pyrite, are not (13). We now find that proustite resists completely the decomposing solutions named, while pyrargyrite is decidedly attacked by the nitro-citric mixture as well as by the iodo-citric mixture, even in the cold.

This difference in behavior of the two closely allied minerals was established by numerous determinations.

Oxides.

30. The oxides examined include such stable minerals as corundum, spinel, chrysoberyl, cassiterite, rutile, hyalite, and quartz, which naturally resist these methods of attack.

Gummite is attacked by cold citric acid, and melaconite and goethite are soluble to a certain extent on heating. Menaccanite and washingtonite are feebly attacked by the nitro-citric mixture and strongly by the iodo-citric solution. This latter also strongly attacks braunite and goethite.

SILICATES.

31. Silicates are very unequally attacked by citric acid as well as by mineral acids.

(*a*) Nephelite, lapis lazuli, laumontite, herschelite, thomsonite, mesolite, and prochlorite, are decomposed by citric acid in the cold, a portion of them with formation of a jelly.

Tephroite, ilvaite, gieseckite, jefferisite, heulandite, and genthite, are strongly attacked on boiling with the citric acid alone. Pargasite, pyrope, almandite, colophonite, phlogopite, bastite, masonite, and allanite (?), are feebly attacked. Some doubt obtains, however, as to the last named, because the specimens examined were partially decomposed on the surface.

(*b*) The addition of sodium nitrate to the solution of citric acid does not notably increase its solvent power as respects silicates, but the addition of potassium iodide aids decidedly in effecting their decomposition. The iodo-citric mixture strongly attacks the garnets named, as well as enstatite, hypersthene, pargasite, epidote, and those named in paragraph 32.

The feldspars resist these reagents, yet orthoclase and labradorite give up iron to them. Petalite, actinolite, asbestus, beryl, zircon, vesuvianite, zoisite, iolite, lepidolite, leucite, andalusite, fibrolite, topaz, titanite, staurolite, and kaolin, either wholly resist or give to the attacking solution only a trace of iron.

The variety of serpentine known as bowenite resists citric acid, while serpentine itself, of a normal character, is decomposed.

On the whole, citric acid attacks the silicates with a power nearly approaching that of hydrochloric acid.

REVISION OF THE SILICATES.

32. While carrying on these researches we were continually compelled to combat the firmly grounded impression that the organic acids are weak as respects mineral species. In conse-

quence of this pre-conceived notion, we overlooked in our first paper the fact, that the decomposition of many silicates takes place at ordinary temperatures, having in fact applied heat at once when conducting the examination.

A closer investigation, however, shows that a saturated solution of citric acid is able to decompose many silicates in the cold, even to the formation of gelatinous silica. This necessitated a revision of the silicates named in our first paper (16), with the following results :—

(*a*) Willemite, pectolite, calamine, natrolite, wollastonite, chrysolite, chondrodite, chrysocolla, apophyllite, rhodonite, analcite, chabazite, stilbite, and deweylite, are more or less strongly attacked by cold citric acid,—the first four yielding a jelly.

Datolite, prehnite, serpentine, chrysotile, and retinalite, are attacked on boiling the solution.

(*b*) The use of the iodo-citric solution as a solvent having been discovered subsequent to the examination of the silicates named in our first paper, a further revision of this group became necessary. The results are briefly as follows :—

Olivine, augite, almandite, and epidote, heated with the iodo-citric mixture, are strongly attacked. Orthoclase, labradorite, hornblende, and spodumene, are very feebly attacked, or yield only iron to the solution.

Wernerite, albite, diopside, kyanite, talc, muscovite, biotite, ripidolite, and tourmaline, are not attacked.

These changes do not invalidate the accuracy of our published results, and are introduced simply to explain the change in position of these minerals in the Tables at the close of this paper.

Sundry Minerals.

33. Under this head are grouped phosphates, arseniates, tungstates, sulphates, etc., as stated in the list given in (27).

A large number, chiefly phosphates, dissolve easily in a cold solution of citric acid ; these embrace the following :—

Mimetite, triphylite, triplite, libethenite, olivenite, ataca-

mite, pseudomalachite, wavellite, pharmacosiderite, torbernite, autunite, ulexite, cryptomorphite, and brochantite. Wulfenite and crocoite are strongly attacked on boiling, the latter yielding a green solution, owing to the reducing action of the organic acid on the chromic acid.

Columbite and wolframite are attacked by the iodo-citric mixture, at least so far as partially to dissolve the iron which forms one of their constituents.

Hübnerite is attacked by the nitro-citric mixture; while scheelite, barite, celestite, anhydrite, and graphite, resist completely these methods of attack.

Native Elements.—In our first paper we called attention to the solvent power of the nitro-citric mixture, as shown by the fact that it dissolves metallic copper, silver, lead, tin, bismuth, and antimony, besides iron, zinc, and magnesium, (20); to this list we now add arsenicum and mercury.

Tabulation of Results.

34. In paragraph (22) we gave a table showing the behavior of ninety minerals with citric acid and other reagents, arranged under eleven heads, viz. :—

A. Minerals which dissolve in cold citric acid without evolution of gas.

B. Minerals which dissolve in cold citric acid with liberation of carbonic anhydride.

C. Minerals which are decomposed by cold citric acid with evolution of sulphuretted hydrogen.

D. Minerals which dissolve in hot citric acid without evolution of gas.

E. Minerals which dissolve in hot citric acid with liberation of carbonic anhydride.

F. Minerals which are decomposed by hot citric acid with evolution of sulphuretted hydrogen.

G. Minerals which are decomposed by hot citric acid with formation of gelatinous silica.

H. Minerals which are decomposed by hot citric acid with separation of slimy silica.

I. Minerals decomposed by boiling with citric acid and sodium nitrate.

K. Minerals decomposed by heating with citric acid and ammonium fluoride.

L. Minerals which are not attacked by any of these methods.

To this we added, in a subsequent paper, a twelfth group, viz. :—

M. Minerals decomposed by heating with citric acid and potassium iodide.

In the Tables accompanying this paper we have combined, on a similar plan, the results obtained in the present and previous communications, thus giving a comprehensive view of the behavior of two hundred minerals with citric acid. The arrangement differs somewhat from the foregoing ; we have re-adjusted the silicates to accord with facts stated in (32), and we have omitted the reaction with ammonium fluoride as of no importance in determining species.

To ascertain the exact position for each mineral has been no trivial task ; and should errors be discovered, we crave indulgence, and beg our friends to remember the French saying : "*Ceux qui ne se trompent jamais sont ceux qui ne font rien.*"

Summary.

35. The number of minerals examined, though considerable, if we regard the labor involved, is but small compared with those which remain to be treated by these methods, and any attempt at generalization must be correspondingly weak.

It may, however, be admissible to study the Tables with a view to determining whether there is any relation, peculiar to the organic acid, between its solvent power and the chemical constitution of the minerals. This question may be considered from two standpoints, corresponding to two methods of classifying minerals, viz., with reference to their acidic and to their basic constituents.

(*a.*) The first method of grouping the minerals is the same as that of the list given (27) ; the question applied to them may be answered thus :—

All carbonates and phosphates are decomposed by citric acid.

The sulphides are very unequally attacked ;—two resist the solvents, three yield only to the iodo-citric mixture, twenty-two only to the nitro-citric mixture, and ten are attacked by the acid alone. The oxides and anhydrous silicates are very unequally attacked.

The hydrous silicates are (with one or two exceptions) decomposed by citric acid alone.

(*b.*) An examination of the influence of the basic constituents on the solubility discloses the following points.

All the copper minerals are soluble in one or more of the solvents.

All the manganese minerals are decomposed,—the sulphide and the silicates with great facility.

All the lead minerals are decomposed by citric acid alone. In some cases the presence of lead would seem to render a mineral easily broken up ; this is marked in the case of the sulphides, which, as we have seen, are very unequally attacked ;—thus selenide of lead is attacked and selenide of mercury is not ; sulphide of lead is attacked, while sulphide of silver is not. The minerals jamesonite, bournonite, and boulangerite (containing lead) are attacked, while the closely allied species stephanite, tennantite, polybasite, proustite, berthierite, etc. (devoid of lead) are not decomposed.

These facts may possibly point to a connection between chemical constitution and solubility, peculiar to the reagent employed ; but we offer the suggestion with diffidence, owing to the limited number of facts on which to base generalizations. Moreover we find that the results obtained by the *prolonged* action of citric acid on minerals (10 to 30 days), differ greatly from those here recorded. To this we shall return at a subsequent period.

In conclusion, we beg leave to remind our readers that the immediate object in view, as was stated at length in our first paper, is the practical application of these methods to the examination of minerals in the field.

Trinity College, Hartford, Conn.

Tables showing the Behavior of certain Minerals with Citric Acid, alone and with Reagents.

I.

DECOMPOSED (IN FINE POWDER) BY A SATURATED SOLUTION OF CITRIC ACID.

1.—IN THE COLD.

A. *Without evolution of Gas.*	B. *With liberation of CO_2.*	C. *With liberation of H_2S.*	D. *With separation of SiO_2.*
Clausthalite,	Calcite, !	Stibnite,	Wollastonite,
Leucopyrite,	Dolomite,*	Galenite,	Rhodonite, !
Atacamite,	Gurhofite, !	Alabandite,	Chrysolite,
Brucite,	Ankerite,*	Sphalerite,	Willemite, !‡
Gummite,	Rhodochrosite,*	Pyrrhotite.	Nephelite,
Pyromorphite,*	Smithsonite,*		Lapis lazuli,
Mimetite,	Aragonite, !		Chondrodite,
Triphylite,	Witherite, !		Pectolite, !‡
Triplite,	Strontianite, !		Laumontite, !‡
Vivianite, !	Barytocalcite, !		Chrysocolla, !
Libethenite, !	Cerussite, !		Calamine, !‡
Olivenite, !	Malachite, !		Apophyllite,
Pseudomalachite,	Azurite.*		Thomsonite, !
Wavellite,			Natrolite, !‡
Pharmacosiderite !			Mesolite, !
Torbernite,			Analcite,
Autunite,			Chabazite,
Ulexite, !			Herschelite,‡
Cryptomorphite, !			Stilbite,
Anglesite,			Deweylite,
Brochantite. !			Prochlorite.

2.—ON BOILING.

E. *Without evolution of Gas.*	F. *With liberation of CO_2.*	G. *With liberation of H_2S.*	H. *With separation of SiO_2.*
Cuprite, !	Hausmannite, †	Bornite,	Tephroite, ‡
Zincite,	Pyrolusite, !†	Jamesonite, *	Ilvaite,
Melaconite,	Manganite, †	Bournonite,	Phlogopite, *
Goethite, *	Psilomelane, !†	Boulangerite,	Datolite, !‡
Limonite, *	Wad, !†	Kermesite.	Prehnite, *
Allanite, (?)	Magnesite, !		Heulandite,
Apatite, *	Siderite. !		Serpentine,
Wolframite, *			Chrysotile,
Wulfenite,			Retinalite,
Crocoite,			Bastite,
Gypsum.			Genthite,
			Gieseckite, *
			Jefferisite,
			Masonite. *
and those in A.	*and those in B.*	*and those in C.*	*and those in D.*

II.

DECOMPOSED BY A BOILING SOLUTION OF CITRIC ACID, MIXED

I.—WITH SODIUM NITRATE.		K.—WITH POTASSIUM IODIDE.	
Silver,	Cobaltite, !	Realgar, *	Almandite,
Mercury,	Ullmannite, !	Orpiment, *	Pyrope,
Copper,	Marcasite, !	Cinnabar, !	Colophonite,
Arsenic,	Arsenopyrite, !	Hematite, *	Epidote.
Antimony,	Nagyagite,	Menaccanite, *	
Bismuth,	Covellite, !	Washingtonite, *	
Sulphur, *	Berthierite, !	Magnetite, *	
Bismuthinite,	Pyrargyrite,	Franklinite,	
Domeykite, !	Tetrahedrite, !	Braunite,	
Argentite,	Tennantite, !	Enstatite,	
Hessite,	Stephanite,	Hypersthene,	
Chalcocite, !	Polybasite, !	Augite,	
Tiemannite, !	Enargite, !	Spodumene, *	
Millerite, !	Uraninite, !	Hornblende, *	
Niccolite, !	Hübnerite.	Actinolite, *	
Pyrite, !		Pargasite, *	*and most of those in*
Chalcopyrite, !		Olivine,	*A, B, C, D, E, F, G, H, and I.*
Linnaeite,	*and those in C and G.*		
Smaltite, !			

III.

MINERALS NOT DECOMPOSED BY THE ABOVE REAGENTS.

Graphite,	Iolite,	Talc,	Labradorite,
Molybdenite,	Biotite,	Kaolin,	Oligoclase,
Proustite,	Muscovite,	Ripidolite,	Albite,
Fluorite,	Lepidolite,	Columbite,	Orthoclase,
Cryolite,	Wernerite,	Samarskite,	Tourmaline,
Corundum,	Leucite,	Spinel,	Scheelite,
Diopside,	Andalusite,	Chromite,	Barite,
Petalite,	Fibrolite,	Chrysoberyl,	Celestite,
Asbestus,	Kyanite,	Cassiterite,	Anhydrite.
Beryl,	Topaz,	Rutile,	(Two hundred
Zircon,	Titanite,	Quartz,	species.)
Vesuvianite,	Staurolite,	Hyalite,	
Zoisite,	Bowenite,	Anorthite,	

N. B.—The gases evolved are examined with acetate of lead test-paper the solutions with appropriate reagents.

The kind and degree of action are indicated in the above Tables by the following signs :—

! Completely decomposed or dissolved.

* Feebly attacked.

† The CO_2 evolved is derived from the Citric Acid.

‡ Gelatinizes.

II.—*The Place of Sadi Carnot in the History of Thermotics.*

BY PROF. R. H. THURSTON.

Read April 5th, 1880.

M. Hirsch, in his Introduction to his translation of the writer's History of the Steam Engine,* publishes a new fact relating to Carnot and the history of the mechanical theory of heat, as revealed in recently discovered documents, which had only come to his knowledge at the time of writing.

The documents referred to, were presented to the President of the Academy of Sciences by M. H. Carnot, November 30th, 1878. They show clearly, that if the doctrine of the equivalence of heat and mechanical energy was not recognized by Sadi Carnot when, in 1824, he published his now celebrated work, "*Reflexions sur la Puissance Motive du Feu,*" the idea of the identity of the two forms of energy soon did become recognized by him and observable in the course of his work.

The following are extracts from the manuscript notes left by Carnot :—

"La Chaleur n'est autre que la puissance motive, ou plutôt, que le mouvement qui a changé de forme. C'est un mouvement dans les particules des corps. Partout où il y a destruction de puissance motive, il y a, en même temps, production de chaleur en quantité précisément proportionelle à la quantité de puissance motive détruite. Réciproquement, partout où il y a destruction de chaleur, il y a production de puissance motive."

"On peut donc poser en thèse générale que la puissance motive est en quantité invariable dans la nature, qu'elle n'est jamais, à proprement parler, détruite. A la vérité, elle change de forme, c'est-a-dire qu'elle produit tantôt un genre de mouvement, tantôt un autre ; mais jamais elle n'est anéantie."

[Heat is nothing else than motive power (energy), or rather, a motion which has changed its form. It is a motion of the molecules of bodies. Whenever motive power is destroyed, there is, at the same time, a production of heat in quantity precisely proportional to the quantity of power destroyed. Reciprocally,

* Histoire de la Machine à Vapeur, par R. H. Thurston, Prof. of Mechanical Engineering at the Stevens Institute of Technology. Revised, annotated and enlarged by J. Hirsch, Prof. of the Steam Engine at "Ecole des Ponts et Chaussées de Paris ;"—Vol. I, p. XV, foot note.

wherever there is destruction of heat, there is production of power of motion.

We may then state as a general law, that energy is, in nature, invariable in amount; that is, is never, properly speaking, either created or destroyed. In fact, it changes form; that is, it causes sometimes one kind of motion, sometimes another; but it is never destroyed.]

Again:

* * * * D'après quelques idées que je me suis formé sur la théorie de la chaleur, la production d'une unité de puissance motive nécessite la destruction de 2.70 unités de la chaleur (chaque unité de puissance motive, ou dynamie, représentant le poids de 1 mètre cube d'eau élevé à 1 mètre de hauteur."

[* * * * According to my ideas of the theory of heat, the production of a unit of energy demands the destruction of 2.70 units of heat (each unit of energy, or *dynamie*, representing the raising of the weight of one cubic meter of water one meter high.]

This estimate gives for the value of the "mechanical equivalent of heat," $\frac{1000}{2.70} = 370$, roughly approximating 424, the metric equivalent of 772 foot-pounds, the British unit of heat-equivalence.

M. Hirsch remarks upon the precision with which Carnot states the law of equivalence of heat and work, as well as the more general law of the "conservation of energy." The considerations which lead him to this last-named law are of the extremest simplicity.

Still more: Carnot lays out a complete programme of experiments on heat and energy—the very experiments since made by Joule, Thompson, Hirn, Regnault, and others.

Hitherto, Carnot has been credited with the invention of the standard method of examination of the relations between heat and work, and it has been assumed that he was, to the last, a believer in the materiality of heat. His idea that we can only infer this relation after studying processes of such nature as present a complete cycle of changes resulting in the perfect restoration of the primitive physical conditions observed in the working substances, and his proposition that the reversible engine is the perfect engine, have admittedly formed the basis

of modern thermodynamic investigation. Prof. Tait justly asserts* that, without this basis, the dynamical theory of heat could never have obtained, in so brief a period, the wonderful development witnessed during the past half-century. Carnot's imperfect enunciation and demonstration of these points, remained unfruitful until, a quarter of a century later, Thompson and Rankine commenced their work in this field. The former then called attention to the work of Carnot,† and adapted his conception to the dynamical theory and perfected the typical cycle.

Carnot's original work contains no evidence that he accepted the dynamical theory of heat, and it has only now become evident that, if not then aware of the falsity of the material hypothesis, he soon became conscious of it, and fully accepted the true theory.

His value (370) for the dynamical equivalent, is not nearly as close an approximation as that obtained by earlier investigators. Rumford, especially, not only accepted, and in 1798 published in the Philosophical Transactions, a complete and definite statement of the equivalence of heat and work, but gave data, as shown by the writer,‡ giving the value 783.8 foot-pounds, or within 1-5 per cent. of the now accepted value. This fact, however, while creditable to Rumford as the first correct expounder and the experimental discoverer, does not detract from the honor due Carnot as the propounder of his method.

It is certainly unfortunate that the manuscript notes left by Carnot could not have been published by him; and still more unfortunate is it that he had not earlier announced his belief and incorporated the dynamical theory of heat in his great work. His already great reputation, as it is, will be hightened by their tardy publication; but had he made the "Reflexions" the vehicle of their presentation, Carnot would indisputably have earned the position, which is now sometimes denied him, of the founder of the modern science of heat-dynamics.

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* Recent Advances in Physical Science.

† See Tait's History of Thermodynamics:—also, Phil. Mag., 1872.

‡ Trans. American Society of Civil Engineers, 1873.

III.—*Upon the Production of Peroxide of Hydrogen, as well as of Ozone, by the action of moist Phosphorus upon Air.*

BY ALBERT R. LEEDS.

Read March 8th, 1880.

In various preceding papers, and more especially in one entitled "Upon Ammonium Nitrite, and upon the By-products obtained in the Ozonation of Air by Moist Phosphorus," (J. Am. Chem. Soc., I, p. 145; Ann. der Chem., CC, p. 286), I have strongly insisted upon the fact that Peroxide of Hydrogen always accompanies the ozone generated by the aerial oxidation of phosphorus. Moreover, that the amount of peroxide of hydrogen, under definite circumstances of temperature, exposure of surface, etc., stands in a certain ratio to that of the ozone. So intimate appears to be the connection in the causes which invariably produce both bodies in this case, that any explanation which aims to account for the production of ozone in the action of air upon moist phosphorus, and ignores the simultaneous generation of peroxide of hydrogen, must of necessity be faulty.

Without invalidating any of the experiments above alluded to, or the inductions therefrom, Mr. C. T. Kingzett has recently asserted* that there is no evidence whatsoever, that any ozone is produced during the slow oxidation of phosphorus. Further, that the body supposed in this instance to be ozone, is in reality only peroxide of hydrogen. The same is true of Prof. McLeod, who followed the above with the contradiction,† that no peroxide of hydrogen is produced under these circumstances, but ozone only. An inspection of Prof. McLeod's experiments, shows that they must have been open to some source of fatal error, because, instead of showing a progressively diminishing amount of ozone with the successive increments of temperature to which the stream of ozonized gas was subjected, they exhibit at 200° the largest proportionate yield of ozone. Had the experiments been correctly performed, they would have shown *no ozone* at 200°, ozone undergoing resolution into ordinary oxygen almost entirely and immediately (97 p. c. immediately) at this temperature.

* Chem. News, XL, p. 96.
† Chem. News, XL, p. 307.

The purpose of the present article, is to demonstrate by a method entirely different from that which I have previously employed :—

I. That *both* hydrogen peroxide and ozone are generated by the action of air upon moist phosphorus.

II. That in this highly dilute condition, they are not completely destroyed, even after prolonged intermixture.

III. When the current of ozonized air, containing hydrogen peroxide, is passed through a tube heated to various temperatures, the amount of water, obtained by the decomposition of the hydrogen peroxide, *increases* with the increment of temperature.

IV. That, under these circumstances, the amount of ozone regularly diminishes. At 200°, no ozone reaction whatsoever is obtained.

V. That after this point has been attained, if a solution of potassium iodide (entirely free from iodate), which has previously been acidified with sulphuric acid, be substituted for the neutral solution employed to titrate the ozone, it will undergo slow decomposition. This result is due not to ozone, which is completely destroyed by continued exposure to a temperature of 200,° but to the spontaneous decomposition of an acidified solution of potassium iodide in presence of oxygen.

The objects kept prominently in view, in devising the method of the experiment, were :—

1*st.* To bring filtered and purified air in contact with a large surface of phosphorus, the phosphorus being partly immersed in distilled water quite free from ammoniacal and nitrous compounds, and maintained during the course of the experiment at the temperature of maximum evolution of ozone (24°—25° C).

2*d.* To wash out of the ozonized air as large an amount of hydrogen peroxide as possible, by means of an extended series of wash-bottles.

3*d.* To free the ozonized air, after its escape from the wash-bottles, from every trace of moisture.

4*th.* To decompose the hydrogen peroxide and ozone at gradually increasing temperatures.

5*th.* To weigh any water, and to titrate any ozone, remaining after the ozonized air had been subjected to the action of heat.

These views were embodied in the apparatus shown in Plate I. The air was filtered through a train of purifiers, of which *A*

contained absorbent cotton, *B* and *C* glass beads drenched with soda solution, *D* and *E* sulphuric acid beads. The air, after ozonation in the "Phosphorus Ozonator," was aspirated through Kerite tubing into the first wash-bottle, and thence into the four Geissler bulbs *F*, *G*, *H* and *I*, the entire five containing water. From *I*, the gas passed through the empty wash-bottle *J*, thence into the sulphuric acid wash-bottle *K*, and finally through three drying-tubes, filled to a length of 2½ meters with glass beads drenched with sulphuric acid.

From the dryers, the ozonized air passed into a curved glass tube, *N*, dipping down into an oil-bath *M*. The middle portion of this tube, for a length of 0.25 meter, was filled with amianthus which had previously been ignited. The object of this amianthus filling, was to cause the ozonized air to pass through a great extent of heated air passages. After this, followed a weighed sulphuric acid drying-tube *P*, a sulphuric acid guard-tube *T*, and a Geissler bulb containing a neutral solution of potassium iodide *W*. Between *P* and *S*, an empty tube closed with corks at both ends was interposed, for convenience in slipping out the drying-tube *P*.

The following experiments were performed under as nearly as possible identical conditions. Twelve liters of ozonized air were drawn through the apparatus in each trial, at the rate of six liters per hour. The ozonator was maintained at the temperature of 24° C. The increase in weight of the drying-tube *P*, corresponded to the water formed by decomposition of the hydrogen peroxide when heated to the various temperatures indicated in the table. The amounts of iodine set free in the potassium iodide solution, are calculated into the corresponding amounts of ozone, according to the equations :—

$$2\,KI + O_3 + 2\,HCl = 2\,KCl + I_2 + H_2O + O_2 \text{ and}$$
$$2\,KIO_3 + 2\,HCl = 2\,KCl + I_2 + O_2 + H_2O,$$

each molecule of ozone corresponding to two atoms of iodine. A large number of trials were made in blank, the ozonator not being thrown into action, and when at last the adjustment was made so perfect that the drying-tube *P* did not alter in weight either at 20° or 200°, when 12 liters of air were aspirated through the apparatus, and the potassium iodide solution in *W* underwent no alteration under like circumstances, the experiments given below were performed.

Table showing the effect of Temperature upon the Hydrogen Peroxide and Ozone contained in Air ozonized by Phosphorus.

Exp.		Temp.	Water.	H_2O_2.	Ozone.
1st Series	I	100°	0.0015 grm.	0.0028 grm.	not determ.
	II	50°	0.0010 "	0.0019 "	"
	III	24°	0.0000 "	0.0000 "	"
2d Series	IV	200°	0.0010 "	0.0019 "	0.000 grm.
	V	200°	0.0011 "	0.0020 "	0.000 "
	VI	150°	0.0002 "	0.0004 "	0.0011 "
3d Series	VII	100°	0.0015 "	0.0028 "	0.0013 "
	VIII	50°	0.0003 "	0.0006 "	0.0044 "
	IX	21°	0.0000 "	0.0000 "	0.0037 "
4th Series	X	200°	0.0018 "	0.0034 "	0.0000 "
	XI	100°	0.0002 "	0.0004 "	0.0011 "
	XII	22°	0.0000 "	0.0000 "	0.0051 "

These experiments, it appears to us, conclusively establish the truth of the first, second and fourth propositions. They show that *both* hydrogen peroxide and ozone are formed, and that on heating the ozonized air, the proportion of water thus formed regularly increases, while that of the ozone as regularly diminishes, until at 200° all the hydrogen peroxide is converted into water, and all the ozone into ordinary oxygen.

At the close of the twelfth experiment, the intermediate train of dryers, etc., was thrown out, and the Geissler bulb *W*, containing the potassium iodide solution, was connected directly with the first wash-bottle (that preceding *F*). The same volume of ozonized air, at the same rate, being drawn over under these conditions, gave a result corresponding to 7.94 mgrms., instead of 5.1 mgrms., as in experiment XII. The difference of 2.84 mgrms., which is 36 p. c. of the amount of ozone originally evolved, represents the loss due to the decomposition effected by the simultaneous presence of hydrogen peroxide.

This establishes the second proposition, and shows not only that the hydrogen peroxide and ozone can co-exist for a long

time in dilute condition without great loss of either,* but also that the amount of hydrogen peroxide in the ozonized gas, bears a not inconsiderable proportion to that of the ozone itself. In fact, neglecting for a moment the minute amounts of hydrogen peroxide that are held back by the wash-waters, *the ratio of the hydrogen peroxide to the ozone in the ozonized air exceeds one to three.*

The amounts of hydrogen peroxide held back by the wash-waters were as follows:—The bulb *F*, containing 47 cc of water, after evaporation to two-thirds its original volume, in order to expel any dissolved ozone, was found to contain 0.2 mgrm. H_2O_2. The bulb *G*, containing 26 cc. water, after being similarly evaporated, gave a reaction corresponding to 0.08 mgrm. H_2O_2. The bulb *H*, to 0.01 mgrm. H_2O_2. The falling off in the amount of hydrogen peroxide contained in *H*, in comparison with that in *G*, is perhaps greater than should be, for the reason that *H* and *I* were changed during the experiments, and a much smaller amount of ozonized air passed through them than through the two preceding bulbs. But the striking feature in the experiment is, that only 0.3 mgrm. H_2O_2 in all was absorbed by the wash-waters, the remainder passing on in the stream of ozonized air.

Finally, to determine the truth or falsity of proposition V:—That the air, after being deprived of its hydrogen peroxide and ozone, could bring about a decomposition of an *acidified* solution of potassium iodide,—the experiment was again repeated with the tube *N* maintained at a temperature of 200°. It will be noted that in every preceding trial at this temperature, a neutral solution of iodide being used, no liberation of iodine occurred. But in this experiment, a decomposition took place corresponding to 0.2 mgrm. of ozone. This experiment, therefore, proves that the oxygen contained in a current of air, from which every trace of hydrogen peroxide and ozone has been removed by strong heating, may produce apparently the ozone reaction, *in case the potassium iodide solution used for titration has been acidified.*

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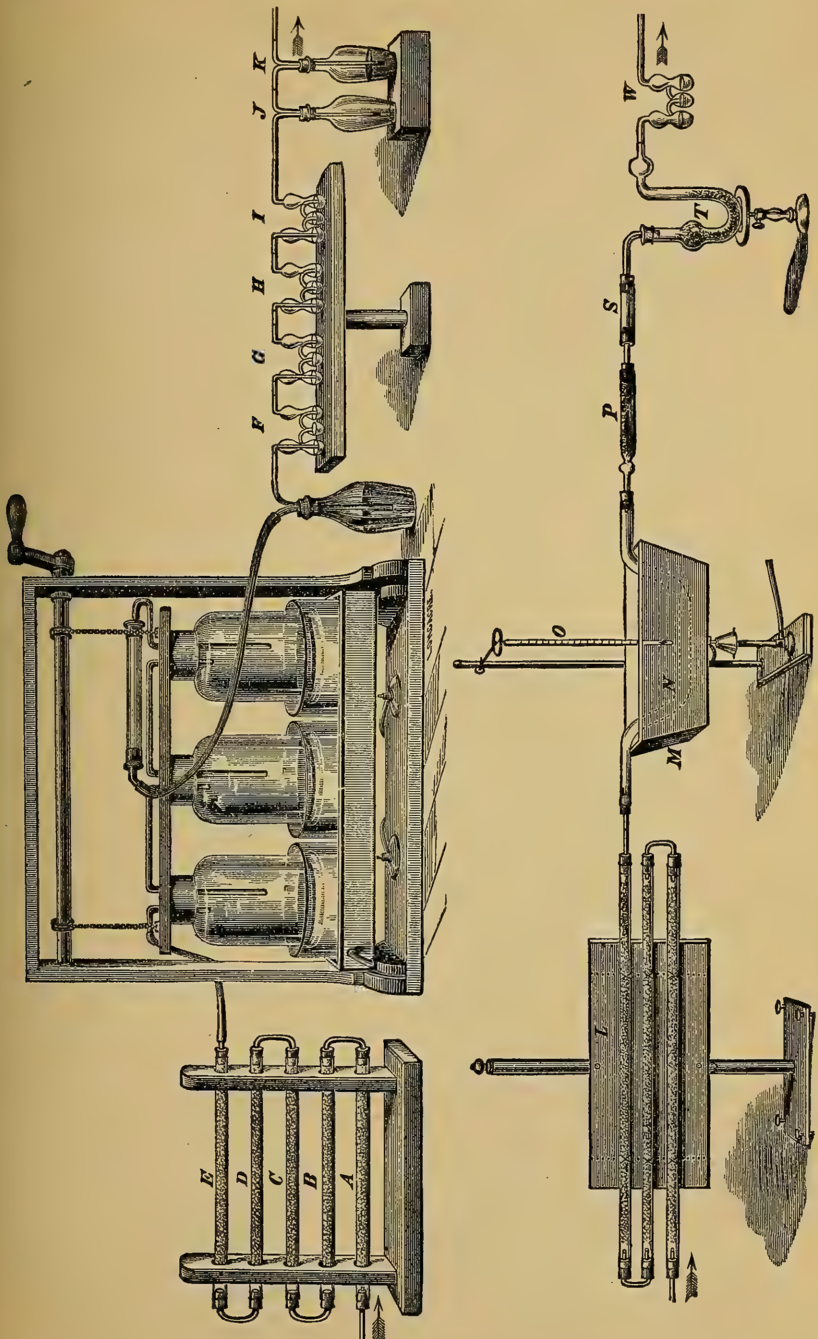
* This point, in opposition to the statements of Schönbein, has likewise been established by Schöne. Jour. für Prakt. Chem., LXXVI, p. 130, and Ann. der Chim., CXVI, p. 240.


A
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IV.—*On the Geology of Hudson County, New Jersey.*

BY ISRAEL C. RUSSELL.

Read April 19th, 1880.

The eastern boundary of Hudson County is the middle of the Hudson River; at Bull's Ferry the line leaves the river and bears northwest until Bellman's Creek is reached, which it follows to the Hackensack River; thence the latter stream is the boundary, to the mouth of Sawmill Creek, which comes in from the westward; the boundary then follows Sawmill Creek to the point where that stream is crossed by the Belleville turnpike, which then becomes the boundary as far as the middle of the Passaic River; the line then follows the centre of that river to Newark Bay, and then through the centre of the bay to the Kill Von Kull, through which it passes and joins the eastern boundary.* The area thus inclosed comprises about 51 square miles, of which 6.4 sq. m. are covered by water.

The most prominent feature in the geology as well as in the geography of Hudson County, is the great ridge of trap-rock which traverses it from north to south, and forms the elevated portion known in different parts of its course as Bergen Hill, Jersey City Hights, Hights of Weehawken, etc. This same ridge of trap continues northward, forming the bold, picturesque Palisades along the west bank of the Hudson; at Haverstraw, where an elevation of over a thousand feet is attained, the trap-ridge sweeps around sharply to the westward, forming the Hook Mountains, so well known to all who are familiar with the beautiful scenery of the Hudson.

In order to understand the topography of the region we are studying, it is necessary to remember that this ridge, forming the back-bone of the county, is the outcropping edge of an immense irregular sheet of very hard crystalline rock, which dips

* For more detailed information, consult Public Laws of N. J., 1840, p. 65.

westward at an angle of about fifteen degrees, thus giving the western side of the hill a drainage in that direction. On the west, the trap passes beneath the sand-dunes and swamp-deposits of the Newark meadows. To the eastward, this outcropping sheet of rock presents a bold mural escarpment, frequently forming cliffs from one to two hundred feet in height. having usually a bank or talus at the base, composed of huge angular fragments of trap that have been broken from the face of the precipice, mingled in some places with boulders and boulder-clay that can only be referred to the glacial drift. The appearance presented by the outcropping edge of this trap-sheet to the eastward is typically shown in the Palisades.

The relation that the trap bears to the softer sedimentary strata of Triassic age associated with it, is represented in the section across Hudson County accompanying this paper. On either side of the conspicuous hill of trap are beds of sandstone, slate and shale, all inclined to the north-westward at about the same angles as the sheet of trap itself; these sedimentary strata form the bed-rock along each side of the hill, and also of the greater portion of the country for twenty miles west of Hudson County.

Besides the trap-rock, sandstones, slates, and shales already mentioned, there is an area of small extent, underlying the eastern portion of Jersey City, composed of very ancient crystalline gneiss; northward of this, and resting upon it or interstratified with it, occurs a limited exposure of jasperoid-rock and serpentine, composing the hill at Hoboken known as Castle Point.

In the section referred to above, it will be noticed that the older strata forming the rocky floor of the county, are overlaid by a sheet of material of a totally different nature, occurring both on the hill-tops and in the valleys. This covering of earth and stones, now forming the surface of the larger portion of our county, is glacial drift, and will be more fully described under the head of surface geology.

Along the western side of Bergen Hill, this covering of superficial material is overlaid in turn by the sand-dunes and swamp-deposits of the Newark meadows; to the eastward, along

New York Bay, the drift is again concealed beneath similar deposits, which are thus shown to be of a more recent date.

Beginning with the oldest of these formations, and examining each in the order of its age, we hope, by giving what facts we have been able to gather concerning them, to find the position occupied by each stratum in the geological column, and to indicate at the same time the relation borne by the various formations to the prosperity and sanitary condition of Hudson County.

Archæan Rocks.

Gneiss and Mica Schist.—Rocks of this class occur at the very base of the geological column, and are among the oldest strata known; their general appearance is no doubt familiar to most of my readers, from the abundant outcrops of these rocks on Manhattan Island. Wherever the Archæan rock comes to the surface in the neighborhood of New York, it is usually composed of highly crystalline gneiss, mica-schist, hornblende-schist, marble, etc.; all of these were at one time earthy or calcareous sediments, spread out in horizontal layers at the bottom of the Archæan Ocean, and have since been upturned, folded and crumpled into their present contorted forms. During these changes in position, the strata have been altered and metamorphosed by the action of heat and heated solutions, so that they now bear but little resemblance to the sand and mud of which they were originally composed. The minerals now forming these metamorphosed rocks are principally quartz, feldspar and mica, and still retain in their arrangement some indication of the stratified nature of the original deposits. Some of our citizens still remember a reef of this rock, formerly to be seen in Jersey City at low tide, between Washington and Green Streets and north of Harsimus Street; this was a narrow crest, about one hundred feet in length, with nearly vertical walls; the mud near at hand on either side being sixty feet deep. From specimens recently obtained, we learn that the rock forming this reef varied considerably in appearance, some of it being a typical mica-schist, with well-defined layers of mica, etc., while other portions were of gneiss appearing so compact and fine-grained that they re-

sembled some of the trap rock at Bergen Hill at first glance. There was a second reef of the same nature formerly to be seen at the southern end of Washington Street, where it crosses the Morris Canal; this reef was penetrated to the depth of a thousand feet by a well bored at Matthieson and Wiecher's sugar refinery; the rock was reported to be mostly gneiss containing mica and quartz, and near the bottom "white sandstone and shale."(?) Both these exposures of gneiss and mica-schist, underlying Jersey City, have now been covered with earth, and the pier-heads carried beyond them. There is but little doubt that this same line of reefs extends southward of Jersey City, and forms the main portion of Ellis's, Bedlow's and Oyster Islands, and Robbins's Reef. This belt of Archæan rocks reappears on Staten Island, but is soon covered by more recent deposits; it again comes to the surface at Trenton, and is again concealed nearly to Philadelphia, whence it stretches far to the southward. Although this formation has but slight economic importance in Jersey City, further than forming a firm foundation on which to build, and has but little immediate influence on the health of the people, yet its physical history makes it an interesting subject of study for the geologist.

Serpentine.—The serpentine associated with the belt of Archæan rocks that borders Hudson County on the east, is the dark-green variety, as distinguished from the light greenish-yellow or precious serpentine found in other localities. The cliffs overlooking the Hudson at Castle Point, Hoboken, present a fine exposure of this dark-green earthy rock; it shows considerable variation, however, being sometimes yellowish and dull in appearance, and so earthy and incoherent as to crumble between the fingers. In some places it is quite compact, and may be dressed so as to furnish an ornamental although inferior building-stone; it has been used with very pleasing results in constructing the beautiful gateway and porter's lodge at Castle Point.

The hill of serpentine at Hoboken is less than half a mile in length along the river bank, and from two to three hundred feet wide, and covers an area of about thirty acres. Seemingly it is the northern exposure of a belt of this kind of serpentine that has been reached by boring at a depth of 179 feet at the end of

Long Dock, Jersey City, and which appears at the surface in the hills on Staten Island ; some of the deep wells in Jersey City, or at Timbech and Betz's brewery on Ninth Street, near Grove Street,—which at a depth of between 700 and 800 feet penetrated a light-colored rock, that yielded a supply of water strongly impregnated with magnesia,—indicate that they penetrated serpentine or some closely associated rock.

The serpentine outcropping on Manhattan Island, at the foot of 60th Street, near the Hudson, is quite different in its characteristic features from the serpentine appearing at Hoboken ; it is compact, very dark-green or nearly black in color, and is sometimes mingled with calcite, forming an *ophicalcite* that is strikingly similar to the Canadian serpentine in which *Eozoon* is found ; other portions of this serpentine are spangled with flakes of talc, or shot through with bladed crystals of tremolite ; and associated with it occurs anthophyllite.

At a number of localities, both northward and southward, in the New York belt of Archæan rocks, beds of dark-green serpentine are found, bearing sometimes a close resemblance to that occurring at Hoboken ; while the serpentine occurring in the crystalline rocks of the New Jersey highlands, and in the corresponding formation to the eastward, in New England, is commonly the light-colored or precious variety.

At Hoboken, the serpentine appears to rest upon the gneiss rocks which outcrop farther south ; it is probably but a portion of the same series, however, and corresponds in position with the serpentine found so abundantly in the Archæan rocks of other regions. This rock is essentially a silicate of magnesia, and contains also chrome iron scattered through it in small specks and grains ; from the fissures in the rock the magnesian minerals, *marmolite, brucite, nemalite* and *magnesite* may be obtained.

As stated by Mr. Ward,* the serpentine is granular and porous in texture ; absorbs surface-water promptly, thereby greatly promoting natural drainage ; transmits heat very slowly but retains it tenaciously, forming a highly salubrious substratum.

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* Memorandum on the Soil, Contour and Drainage of Hudson County. By L. B. Ward, C. E. Rep of County Board of Health, 1877, p. 8.

Associated with the serpentine at Hoboken, and overlying it, there occurs an exceedingly hard jasperoid rock,* which was formerly to be seen in the neighborhood of the Stevens Institute, but has since been concealed by buildings and park improvements. We have referred this rock to the Archæan series, as will be seen in the generalized section of the rocks of Hudson County, accompanying this essay, but can offer little information concerning it.

Triassic Rocks.

Sandstones, Shales and Slates.—Resting on the upturned and probably eroded edges of the gneiss and mica-schist in Hudson County, are sedimentary beds of Triassic age, which, like the Archæan rocks already noticed, are in most cases but indifferently exposed. The Triassic formation appears usually as evenly bedded strata of reddish-brown standstone and soft reddish shale, together with thinly stratified slates—the whole series dipping towards the northwest with great uniformity at an angle of about fifteen degrees.

On the extreme western border of Hudson County, forming the high narrow ridge that separates the Newark Meadows from the valley of the Passaic River, the reddish-brown sandstones and shales are splendidly exposed. This ridge has nearly as great an elevation as Bergen Hill, and indicates in a very striking manner the vast amount of material that has been removed by erosion from the country now occupied by the Newark meadows. In the deep cut made for the passage of the New York and Greenwood Lake railroad, extending from Arlington to the Passaic River, the strata of reddish-brown sandstones are thinly bedded, the strata seldom being over two feet thick, with partings of red shale between, the whole series inclined at the normal angle of fifteen degrees towards the northwest. One of the most interesting features in this section is the occurrence near the middle of it of a fissure which has parted the rocks in a nearly north and south direction, or parallel to their strike. This fissure is about five feet wide, and is filled in with

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* We adopt the name proposed for this rock some ten years since by Dr. Henry Wurtz.

debris from the red sandstone rocks through which it passes; its walls are altered in texture and color as if by the action of heat, and when freshly broken are of a bright brick-red color. The fragments filling the fissure are small near the walls, and imbedded in an earthy or shaly mass; they are usually rounded and show polished or "slickenside" surfaces. The central part of the fissure is filled with larger masses of sandstone, which show more alteration, both in texture and color, than the walls, and have also slickenside surfaces. The bedding of the sandstones and shales is unaltered where they approach the fissure. The metamorphic action is not confined to the immediate walls of the fracture, but may be traced at least seventy-five or a hundred feet on either side. These facts seem strongly to indicate that the fissure not far below the surface is filled with igneous rock, the heat from which has partially metamorphosed the rocks now exposed. This fissure has still greater interest when studied in connection with the dikes and sheets of trap occurring along the west bank of the Hudson.

It is not out of place to state here, that no fossils were discovered during the construction of the railroad cut at Arlington, and that no foot-prints, rain-drop impressions, sun-cracks, etc., were found; the only markings that occur here are very obscure impressions, that have the general appearance of sea-weeds or worm-burrows. The sandstones and shales here so well exposed give a fair representation of the character of the Triassic rocks covering a large portion of New Jersey, except that in some instances the sandstone is lighter colored and more feldspathic.

Not more than a mile northward of Arlington, and on a line with the fracture we have described as occurring in the railroad cut, the copper-mine near Belleville is situated. This is known as the Schuyler Mine: it has been worked at intervals since 1717, and has been extensively wrought, as the abandoned shafts and galleries testify. The rock here is a light-colored or nearly white sandstone impregnated with the carbonate of copper; the silicate and red oxide of copper are also present. The sandstone is traversed in places by thin sheets of trap, although no dikes or sheets of this rock appear at the surface: it is thus seen that the copper-bearing sandstone here has the same geological relations as that occurring in other places in the Triassic area of

New Jersey; they are contact deposits, very commonly associated with outbursts of trap, and although sometimes making a good showing of ore, yet at least in New Jersey have never proved profitable in working. Copper-bearing sandstone of the same nature as that of the Schuyler mine, is exposed in a small quarry near Arlington, at the base of the bluffs overlooking the Newark meadows.

On the northern side of Snake Hill, the Triassic sedimentary rocks are well shown in the prison quarry, and present their normal dip of 15° N. W. Interstratified with the reddish-brown sandstones and shales, are two irregular beds of light-colored sandstone, from two to four feet thick, impregnated with the carbonate of copper, and closely resembling the sandstone in the old copper-mine at Belleville. On the west side of the hill, where the sandstones are exposed close up to the trap, they have been shattered in every direction, and are light-colored and sometimes pinkish in tint; the dip of the rocks here is from 30° to 35° N. W. The Trias is again exposed on the south side of the hill in a small cut made for the New York and Greenwood Lake Railroad; the rocks are here light-colored sandstone, with partings of shale dipping 14° N. W., and all considerably fractured. The upland adjoining Snake Hill on the northward is also underlaid at a depth of a few feet, as borings show, by sandstones and shales.

A well eighty feet deep, on the Newark turnpike, near its junction with the Belleville turnpike, south of Snake Hill, penetrated the red sandstone which underlies this section of the swamp; other wells in the same region, some of them two hundred feet deep, failed to reach it.*

On the western side of Bergen Neck, the Triassic beds appear, and have been quarried to a limited extent.

On the eastern border of Hudson County, beneath the trap bluffs along the bank of the Hudson, the Triassic sedimentary beds are again exposed. The stratified rocks appear first, commencing at the southward, beneath the trap of Bergen Hill

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* Vide Table No. 1 at the end of this article.

directly northwest of Castle Point; from this point northward all the way to Bull's Ferry, these rocks are exposed, except where cut out by dikes of trap or covered by debris; throughout this whole section we find thinly-bedded, dark-colored slates, feldspathic sandstone, and shale, all of which have been more or less metamorphosed by the heat of the associated trap; the dip throughout this section, except where plainly disturbed by the intrusion of the trap, is N. W. 15°. The details of this series of exposures will be more fully given in connection with the description of the trap-sheets.

The economic importance of the Triassic sedimentary rocks in Hudson County is very limited indeed; the sandstone at Snake Hill has been used for building-stone, but the supply is small and the quality inferior. An attempt has been made to utilize the slaty layer beneath the trap at Weehawken for roofing-slate, but without success. The importance of the quarries of Triassic "brown-stone" in other portions of the State is very great. From the extensive Newark quarries, large quantities of building-stone are furnished for New York and the neighboring cities; great quantities also come from quarries of the same character and age in the Connecticut Valley.

The Belleville copper-mine has already been mentioned; but, although worked more extensively than any of the other copper-mines in the Trias of New Jersey, it has proved, like the rest, little more than a delusion to those interested in its development.

In a sanitary point of view, the inclined strata of alternating layers of sandstone and shale present one of the best substratums that could be desired; not only do the character and inclination of the rock furnish a complete natural drainage, but it is also a poor conductor of heat, and thus retains the warmth at the surface. Unfortunately, this formation has been so deeply eroded and covered by subsequent deposits, that its beneficial influence is but little felt, except in the high ridge bordering the Passaic River.

Trap-Rock.—As already mentioned, trap-rock occurs in thin layers, penetrating the sandstone at the Schuyler mine. In the Newark meadows, midway between Bergen Hill and the highland bordering the Passaic, are the trap-hills called Snake

Hill and Little Snake Hill, rising as islands in the salt marsh. The former of these is 175 feet high, and is about one and a half miles in circumference; the second, situated about 80 rods to the eastward, is very much smaller, with an elevation of 78 feet. These are chimney-like protrusions of trap that have been forced out between the layers of sandstone, causing some disturbance, and are without doubt connected some distance below the surface with the main trap-sheet forming Bergen Hill. The trap-rock protruding at Snake Hill is of the same nature as that forming Bergen Hill, which will be described further on. As already noticed, the sedimentary beds, when they come in contact with the igneous rock forming Snake Hill, are very much shattered, and altered in texture; the trap seems to have followed in a general way the bedding of the sedimentary strata, but has increased the dip of the sandstone on the northwest side to 30° or 35°.

As previously mentioned, the trap-ridge forming the elevated region of Bergen Hill, is a portion of the Palisade range; this ridge is highest at its northern end, and descends quite uniformly towards the south. At Haverstraw, the loftiest summit, called the High Torn, is 1015 feet above the Hudson; opposite Hastings the elevation is 489 feet, the highest point of the ridge in New Jersey; at Guttenberg, near the northern boundary of Hudson County, the elevation is 260 feet; thence it decreases in hight southward, until at Bergen Point the trap has been cut through by the Kill Von Kull. In the northern portion of the county the trap is fully a mile and a half wide, and narrows quite regularly when followed southward.

At a few localities along the eastern shore of Newark Bay, the trap-rock may be observed coming up from beneath the water, with its usual dip of ten to fifteen degrees northwest; it is only along the shore, where the superficial material has been removed, that the trap-rock beneath can be seen; over nearly the whole of Bergen Neck and Bergen Point it is concealed by drift and sand-dunes. On the eastern side of Bergen Neck, near Greenville, the trap protrudes in a dome-shaped mass, showing a *roche-moutonnée* surface, and several bold rounded knobs, also exhibiting glacial action, protrude above the surrounding drift along the Morris Canal, where it passes through the hill.

By far the best exposures of the trap are to be seen in the various railroad cuts and tunnels that have been made through Bergen Hill.

The eastern face of the trap-sheet is exposed southwest of Lafayette, where the N. J. Central Railroad crosses the Morris Canal; thence northward, it appears at intervals in the steep hill-side west of Jersey City. The point of rocks called Fairmount, near the eastern end of the Pennsylvania Railroad cut, is an outlying mass of trap, forming an island in the salt marsh; its isolated position is due to the fact that the trap forming it was intruded among the sedimentary beds—which have since been eroded away—at a lower level than the main sheet of trap to the westward with which it is connected; the trap has been quarried at a number of places near Fairmount, and is well exposed. From this point northward the exposures of trap become more frequent along the eastern slope of the hill, and at length, at the foot of the hill, directly northwest of Castle Point, the base of the trap-sheet is seen resting on metamorphosed slates. At the first locality where the stratified rocks are exposed beneath the trap, they are mostly slaty in structure, with an inclination of fifteen degrees towards the northwest, and are covered uniformly by the trap. About 150 yards north of the first exposure, the metamorphosed slates and quartzites, in beds from a few inches to four feet in thickness, form the lower thirty or forty feet of the cliff, having the usual northwest dip; resting on the uneven upper surface of these stratified beds, the trap occurs, forming the remaining fifty or sixty feet of the hill. The stratified rocks continue to be exposed more or less perfectly, until the face of the precipice turns eastward at nearly a right angle, and forms a bold projecting promontory, on which an observing-tower now stands; at the base of the perpendicular cliffs below the tower, the trap comes down to the level of the marsh, and plainly cuts out the stratified beds which appear on either side of it. Two or three hundred yards southwest of the tower, the stratified slates are exposed in the side of the cliff, some fifty or sixty feet above the marsh, and are inclined at an angle of about 20° towards the *southwest,* showing that they have been disturbed by the intrusion of the trap, Just around the angle of the cliff, northward of the tower, and along the

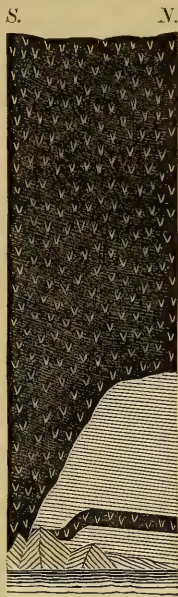
side of the road leading up to Union Hill, the stratified rocks are once more exposed beneath the trap. At the "Hundred Steps" about forty feet of feldspathic sandstone—*arkose*—is exposed beneath one hundred and ten or fifteen feet of trap; the junction between the two being so sharply defined that it may be brought within the field of a microscope, when a flake from the surface of contact has been ground down so as to be translucent.

About eighty yards northward of the high cliffs on which the observing-tower stands, the face of the cliffs forms another angle, where the trap once more breaks through and cuts off the stratified rocks.

Along the Union Hill road, opposite the porter's lodge of Mr. King's estate, the stratified rocks when last seen are between sixty and seventy feet above the river: crossing the little stream known as the Awiehaken, and proceeding to the base of the bold precipice forming King's Point, we find the trap breaking through the sedimentary beds nearly on a level with the Hudson, showing that the main trap-sheet has shifted its position, in reference to the stratified beds with which it is associated, at least forty or fifty feet; or, to speak more accurately, the main trap-sheet has divided, sending out a branching layer of trap from the lower side.

At the base of the cliff forming King's Point, the metamorphosed slates and shales below the trap are cut out, as shown in the following section (Fig. 1), by the breaking through of the trap; the section exhibits, also, an intrusive sheet of trap, an offshoot from the large mass shown in the left of the section, which is a little less than four feet thick; the finely stratified slates, both above and below this thin intruded sheet, are intensely metamorphosed and have a jaspery structure. Tracing this thin bed of trap towards the south, where it approaches the great dike, it cuts through the slates on which it rests, and forces its way in between the layer below; after this change, the borders of the trap-sheet, as exposed in the face of the cliff, are not well defined and are considerably contorted; in places masses of slate have been included in the trap. The junction of this small trap-sheet with the main dike is concealed by debris.

FIG. 1.—SECTION AS EXPOSED IN THE FACE OF THE CLIFF NEAR THE DUEL GROUND, WEEHAWKEN.

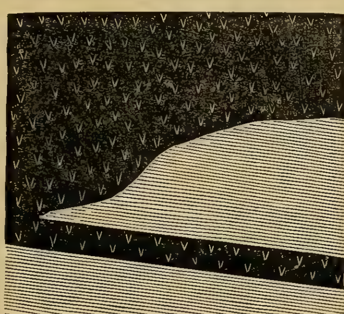


The trap forming the small sheet at the base of the cliff, like that at the base of the main trap-sheet above, is a dark-bluish, fine-grained anamesite, breaking with a conchoidal fracture. The four-feet stratum of trap can be traced northward about seventy yards, when the dip of the rocks carries it below the surface.

Tracing the stratified rocks about 150 yards farther north, we find them somewhat disturbed from their normal position and dipping 30°—35° northwest; a few yards further on they are inclined to the southwest, and a bed of trap four feet thick comes in; this trap is like the first thin bed, is dark-bluish, fine-grained, and yellow on the weathered surface; it is exposed for only a few feet, and is then covered with debris.

About thirty feet above the river, at the point where the sandstones begin to widen out at the base of the cliff to form Day's Point, a division of the trap-sheet is exposed in the face of the cliff, as represented in the following section.

FIG. 2.—SECTION EXPOSED IN THE CLIFFS AT WEEHAWKEN.



The stratified rocks are here of the same nature as in the previous section, and all are very much altered by heat.

From this point, going northward along the banks of the Hudson, the strati-

fied rocks are covered with debris, most of which has fallen from the cliffs of trap that rise above. Just where the upland that projects into the river, forming Day's Point, sweeps back to meet the cliffs once more, the trap again comes down to nearly the level of the Hudson.

Three hundred yards farther north, are the extensive quarries near the Weehawken ferry; there is here a section of about thirty feet of slates and sandstones exposed beneath the trap; at this locality fish-scales and the shells of a Cypris have been found in the slaty rock.

Continuing northward, we find abundant exposures of the sedimentary beds beneath the trap, the light-colored sandstones coming in, however, more abundantly than before.

Just north of Kohler and Sons' brewery, the "seven-story brewery," by the side of a private road that leads to the top of the hill, an irregular trap-dike is seen breaking through the light-colored sandstone that forms the base of the cliff. The dike is four feet thick, and composed of dark-bluish fine-grained anamesite, showing an imperfect columnar structure at right angles to the walls of the fissure.

All the way from Kohler and Sons' brewery to Bull's Ferry, the lower twenty or thirty feet of the cliffs is composed of light colored feldspathic sandstone, the seams in the rock sometimes yielding specimens of dendritic manganese.

At the village of Bull's Ferry, the trap forms a bold angle, and seems to cut out the stratified beds once more, as at King's Point. In the village the metamorphosed slates are again well exposed, with all the characteristics seen at Weehawken. Just north of Bull's Ferry the following section is shown—dip northwest 15°.

Trap-rock, - - - -	120	feet.
Dark heavily-bedded slates, -	45	"
Light-colored sandstone, - -	6	"
Dark evenly-bedded slates, somewhat metamorphosed, - - -	30	" to river.
	201	

The joints of the slate are frequently rounded off and slickensided. Some of the layers of slate near the trap are covered with a net-work of intersecting ridges, looking like casts of shrinkage-cracks; sometimes the under surface of the trap has taken an accurate cast of these markings. The markings mentioned should probably be referred to the action of the heated trap on the material now forming the slate, causing it to crack in imitation of shrinkage-cracks produced when wet mud is allowed to dry in the sun. No ripple-marks, rain-drop impressions or foot-prints were observed, or have ever been reported, from these exposures of Triassic rock.

Bull's Ferry is on the northern boundary of Hudson County; the trap-sheet continues, as we have already stated, northward of this point, forming the Palisades.

On the western side of Bergen Hill, at West End, and farther northwest of Union Hill, there are long ranges of trap parallel with Bergen Hill, now worn and rounded, and separated from it by a narrow area of level land; these appear to be the outcropping edges of thin trap-sheets that branched off from the main sheet on the upper side, in the same manner as those exposed beneath the trap-sheet at Weehawken were formed on the lower side.

Throughout the whole section which we have examined along the bank of the Hudson, there is abundant and cumulative evidence that the main sheet for the most part rests unconformably upon the broken edges of the stratified rocks, but still has followed in a general way the planes of bedding of the sandstones and slates.

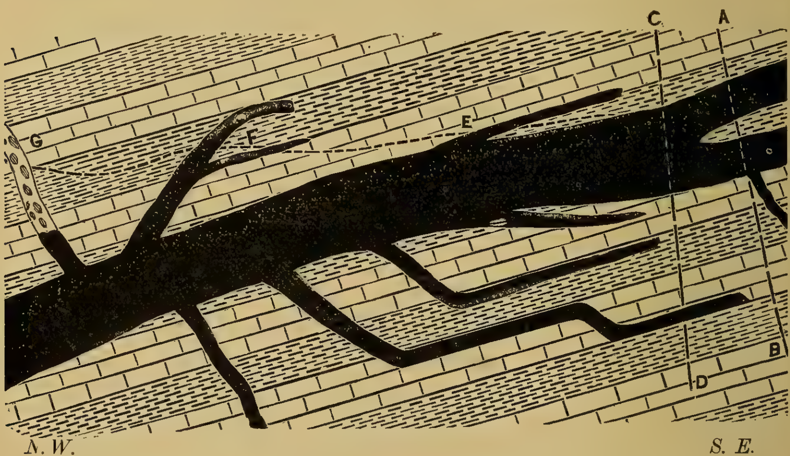
Another phase that the trap-sheets present, is illustrated in the First Newark Mountain, at Plainfield, N. J., where metamorphosed shale is exposed on the top of the trap-ridge three hundred feet above the surrounding plain, with trap both above and below it.

In the same ridge, west of Bound Brook, eight miles southwest of Plainfield, there is a deep valley in the trap which runs parallel with the strike of the ridge. Such a valley could only have been formed by the removal of a mass of stratified rock, which at one time must have divided the trap-sheet, in the same manner as the shale does that is now exposed at Plainfield.

The open fissure at Arlington, which is without doubt filled below with trap, and other thin sheets of the same rock penetrating the sandstone in the Schuyler mine, also aid us in understanding the genesis of the Triassic trap-rocks.

Grouping all these phenomena together, we are enabled to construct an ideal trap-sheet, as it would appear while yet inclosed in the stratified rocks among which it was intruded, or before it was exposed by denudation. A cross-section of such an ideal trap-sheet is shown in the following diagram, which represents a main intrusion of trap like that forming the Palisades or the First Newark Mountain, with its branching or secondary sheets and dikes.

FIG. 3.—IDEAL SECTION OF TRAP-SHEET.



If denudation should have removed the material to the right of the line *C, D*,—an exposure would be made similar to that now seen in the cliffs at Weehawken. Were the rocks above the dotted line *E, F, G*, removed, the trap-sheet at *F* would protrude and form a hill, like Snake Hill and Little Snake Hill, while the sheet *E*, when denuded and rounded off, would correspond with the low ridge of trap along the western border of Bergen Hill. In the same manner, if the accidents of erosion should expose the rocks along the line *A, B*, the conditions now shown at Plainfield and Bound Brook would result. The Arlington fissure is indicated at *G*.

In the cut of the New Jersey Railroad through Bergen Hill, near the western end of the cut, a deep depression occurs in the trap, nearly 900 feet wide; the place once occupied by shale or sandstone is now filled with drift and gravel, and has been quite extensively excavated for railroad ballast, etc. This area appears to be included between the main trap-sheet and the outcropping edge of a smaller secondary sheet to the westward, and extends indefinitely in a north and south direction; it has been excavated to the depth of 30 or 40 feet; the rock bottom, however, is very much lower. Other areas analogous to this may be looked for along the western slope of Bergen Hill, and should receive close attention from those interested in the drainage of this region. The "big pocket" in the Erie tunnel,* appears to have been a mass of metamorphosed shale included between sheets of trap; this locality is but a short distance northward of the hollow cut through by the New Jersey Railroad, which appears to have been eroded from the same series of metamorphosed shale. This included bed of shale was again crossed by the tunnel of the Delaware, Lackawanna and Western Railroad at some distance from the east end of the tunnel; but the rock also fell in, forming a "pocket," as in the Erie tunnel. The reservoir built some time since is situated above this broken area. We are thus furnished with three points on the line of this included stratum of shale.

The trap-sheet that projects eastward of the main ridge, and forms Fairmount Point, can be readily traced to its junction with the main trap-sheet at Newark Avenue; thrust out from the under surface of the main mass, it has followed the bedding of the stratified rocks, between which it cooled; the Jersey City cemetery is situated on this shelf of trap. Passing this ledge a few feet to the eastward, soundings show 70 to 80 feet of mud without reaching rock bottom. Other exposures of dikes or outlying masses of trap may be similarly accounted for.

Wherever the trap is exposed in Hudson County, it appears as a compact dark-bluish rock, impervious to moisture, and usually breaking equally well in all directions. The rock is more

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* "Geology of New Jersey," Prof. Cook, 1868, p. 216.

compact and fine-grained when obtained from the eastern side of the hill, *i. e.*, the lower surface of the trap-sheet. The western or upper surface shows a much coarser texture, and is more difficult to break into regular blocks; for this reason, the rock along the eastern face of the hill is best suited for shaping into paving and building-stones, though the very fine-grained stone at the bottom of the hill is also more difficult to work than the intermediate variety. This difference in the texture of the trap can be readily seen in the cliffs at Weehawken; the rock near the base of the cliff, where it comes in contact with the sedimentary beds below, is very compact, crypto-crystalline, and breaks with a conchoidal fracture; while in the same cliff, a hundred feet above, the separate crystals of augite and feldspar can be distinguished by the unaided eye. The rock that is intermediate in structure furnishes the best paving and building stones.

When a thin chip of the trap-rock is ground down on a lapidary's wheel sufficiently thin to be translucent, it is found, upon examination with a microscope, to consist principally of bladed crystals of augite, sometimes hornblende, and a feldspar, usually oligoclase; these crystals are interlaced in every direction, and frequently interspersed with dark masses of magnetite. It is principally the size of the augite and feldspar crystals, that determines the texture of the rock.*

The crystalline structure of the trap furnishes one of the proofs that it was at some time in a fused or semi-fused condition, and has become a crystalline solid upon cooling. That the trap was forced in between the layers of sandstone and shale, and also injected into fissures therein, forming dikes, we have already given abundant proof. As may be seen in the section along the bank of the Hudson, the stratified rocks beneath the main trap-sheet are always altered and more or less metamorphosed; the junction of the main trap-sheet with the overlying sedimentary beds is not exposed in Hudson County, though it

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* Analyses of the trap from the Erie Railway tunnel in Bergen Hill, are given in Prof. Cook's "Report on the Geology of New Jersey," 1868, pp. 215 and 216, with remarks upon certain of the varieties.

is reported to be shown farther northward at Englewood. The condition, however, of the sedimentary beds resting on the upper surface of one of the trap-sheets is well shown on the western slope of the First Newark Mountain at Feltville. *

In the glacial drift covering Bergen Hill, Weehawken, etc., are many boulders and large irregular masses of metamorphosed shale or slate, identical with the rock outcropping beneath the trap at Weehawken ; these boulders were doubtless derived from the metamorphosed slate overlying the main sheet of trap in the immediate vicinity.

Minerals of the Trap.—The beautiful minerals obtained at Bergen Hill during the construction of the railroad tunnels and cuts, are familiar to all collectors. They are mainly zeolites,—hydrous silicates of alumina and alkalies,—and are the result of the deposition of these substances, in varying proportions, in the cavities and fissures of the trap, whither they have been carried in solution by percolating waters, which, especially under the influence of heat and pressure, have great solvent powers upon the constituents of the trap. †

Economic Importance of the Trap.—The fine-grained rock along the eastern face of Bergen Hill, furnishes an excellent material for paving and building, as it can be broken with ease and certainty into blocks of the desired size and shape; Hudson County produces each year many thousands of such paving-blocks, and the demand will no doubt continue to increase.

The fine-grained trap, when broken into small fragments, furnishes one of the very best materials for macadamizing roads or for railroad ballast; and the chips and waste from the manufacture of paving and building-stones should be utilized for such purposes.

The value of the rock of the Palisade range, as a building-stone, seems to be scarcely appreciated, although there are several examples of its use for substantial edifices : the Stevens Institute of Technology at Hoboken, and St. Joseph's and St. Patrick's churches on the Hights, are constructed of this ma-

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* "On the Intrusive Nature of the Triassic Trap sheets of New Jersey." Amer. J. Sci.,Vol. XV, p. 277, 1878.

† For further reference to the Bergen minerals, see note at the end of this article.

terial. A more durable stone for architectural purposes cannot be easily obtained, and when its somewhat sombre tone is relieved by trimmings of lighter-colored stone, the effect is highly pleasing.

The use of the "brown stone," so abundant in New Jersey and Connecticut, is certainly to be deprecated, especially for the construction of our more costly edifices; even as an ornamental stone, for the lighter portions of buildings, it is far inferior, both in durability and beauty, to the brighter colored and more vitreous Potsdam sandstone from the northern part of the State of New York.

It should be borne in mind, in matters relating to the sanitary conditions of Hudson County, and in the laying out of streets, the building of sewers, the placing of gas and water pipes, etc., that the ridge of Bergen Hill is the outcropping edge of a stratum or bed of impervious rock, inclined to the northwest some 10 to 15 degrees. The upper surface of the hill, especially towards the eastward, is but little affected by this inclination of the strata, as it has been worn down by denuding agencies to a very irregular and uneven plane surface, which has no good natural drainage. The hill owes its elevation not to the upheaval of the rocks composing it, but to the fact that it is formed of harder material than the neighboring beds, and has thus been enabled to resist in a great measure the destruction that has removed the softer stratified rocks that once surrounded and covered it.

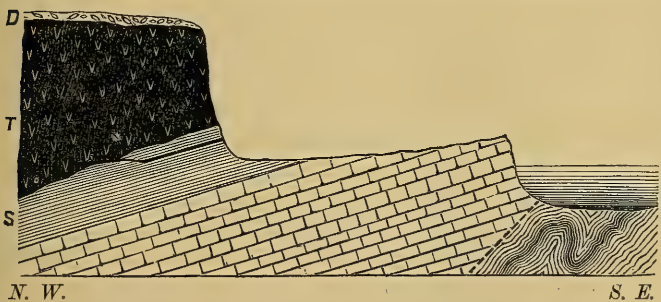
The Triassic Foundation in New Jersey.—The great Triassic area, of which the shales and sandstones so familiar in Hudson County form the eastern edge, has a breadth of about thirty miles, and extends from Stony Point on the Hudson, southward through the State; crossing the Delaware and the Potomac, it reaches in broken areas through Virginia and into North Carolina. The stratified rocks throughout this great region are chiefly interbedded sandstones and shales, usually reddish or brownish in color, including at times some dark thinly-bedded slates and light-colored sandstone; the whole series inclining westward. In New Jersey the dip of 15° N. W. is remarkably persistent.

In the Connecticut Valley, there is another area of Triassic

rocks, extending from New Haven northward, for one hundred and twenty-five miles. These rocks seem identical in their lithological peculiarities, their fossils, etc., with the corresponding beds in New Jersey, save that they dip in the opposite direction. Viewed as a whole, many converging lines of proof tend strongly to show that these eastern and western areas are portions of one great estuary deposit, the central part of which has been upheaved and removed by denudation. The facts upon which this conclusion is based have been presented at length in a previous paper in the Annals of this Academy.*

The abrupt manner in which the stratified rocks are broken off, as shown in the bold line of cliffs on the western bank of the Hudson,—the strata dipping N. W. 15°,—would indicate that the arch must once have been complete, and that the Triassic beds formerly extended far to the eastward of their present limit. The section seen on the bank of the Hudson at Day's Point, two miles above Castle Point, is shown in the following diagram :—

FIG. 4.—SECTION AT DAY'S POINT, WEEHAWKEN.



T represents the main trap-sheet forming the hights of Weehawken, with its top worn down by glacial action and covered with the layer (*D*) of drift. Beneath the trap, the Triassic slates and sandstones compose the base of the cliff, and extend out over five hundred feet into the river, forming Day's Point, and then breaking off in an abrupt cliff at the water's edge; the whole series having the usual dip of 15° N. W. The strata immediately beneath the trap are finely stratified slates or meta-

* Annals of N. Y. Acad. of Sciences, Vol. I, 1878, pp. 220—254.

morphosed shales, (S) while those forming Day's Point are light yellowish feldspathic sandstones.

The igneous rock of the Palisade range also shows that it must have been confined by other rocks on the eastward, now removed, or else the molten rock would have poured out and formed a table-land like those so common in New Mexico. At Haverstraw, as already stated, the trap forms the top of the mountain a thousand feet above the bed of the river. Such facts cannot be explained except by supposing that the igneous rock was inclosed in sedimentary beds at the time of its intrusion. All this may seem a digression, but it is only when we assign the few facts to be gleaned in the geology of Hudson County, to their proper place in the long history of changes and revolutions which our continent has undergone, that we can understand and appreciate their full significance.

During the deposition of the sand and mud now forming our Triassic rock, the Highlands of northern New Jersey formed part of the shore-line that bordered the estuary on the west. Could we have stood beneath the ferns, cycads and spreading coniferous trees which then shaded that picturesque coast, we should have seen over all the region to the eastward—where are now the fruitful farms of New Jersey interspersed with thriving cities and villages—only rolling turbid waters; their eastern boundary far beyond the range of vision. When the tide was out, a broad area of smooth shining mud bordered the shore, closely similar to that now to be seen along the Bay of Fundy at low tide. This plastic surface bordering the old Triassic estuary, was the day-book on which the records of passing events were inscribed. In fancy, we can see the wind rippling the waters as they retreat from the shore, and forming the sand and mud into low parallel ridges or "ripple marks." A cloud obscures the sun, and soon great drops of rain patter on the strange vegetation around; falling upon the soft mud, the rain-drops leave little circular depressions, the nature of which indicates the direction of the wind. In other places, many acres of the muddy surface are crowded with a net-work of intersecting fissures, caused by the shrinking and cracking of the mud when it dries in the sun. From the waters, strange uncouth monsters emerge, and striding over the muddy shores towards the ferns and giant

rushes that border the upland, leave long lines of foot-prints behind them. Mingled with these various markings are here and there the fronds of ferns or cycads, and the twigs and cones from the larger coniferous trees. When the next tide comes in, all these records of physical changes and of animal and vegetable life are covered with a layer of mud and sand, to be preserved for indefinite ages.

That such were the scenes along the base of the New Jersey Highlands in Triassic times, every one can determine for himself.

On breaking open the stony layers, all the records just mentioned may be found as well-defined and legible, after millions of years, as if impressed upon the soft sands but yesterday. In these same beds are found in great abundance the remains of the fishes that swam in the Triassic estuary; these are lepidoganoids (*Catopterus, Ischypterus*, etc.), covered with small diamond-shaped scales, and have their nearest living representatives in the "gar pikes" (*Lepidosteus*) of our northern lakes, and the *Polypterus* of the Nile.

After long subsidence, during which thousands of feet of sediment accumulated in the Triassic estuary, a reverse movement began and the bottom was upheaved, bringing the stratified rocks, especially those of the central region, within the reach of denuding agencies. The gradual folding of the crystalline rocks beneath the Trias ended finally in the fracture of the rocks in long lines parallel with the axis of upheaval. Through these fissures molten rock from beneath was forced out, and found its way into the stratified beds above, sometimes opening the layers and forming intruded sheets of igneous rock, while at other times the stratified beds were fractured, and the injected material filled the fissures and formed true dikes. Examples of each of these modes of occurrence, as already described, are to be seen along the bank of the Hudson. In New Jersey, there are four main lines of fracture through which the igneous rocks escaped; these are now indicated by the long curved mountains of trap that diversify the scenery of the Triassic area. The most easterly of these is the Palisade range; this is bent into the form of a crescent by having its extremities curved abruptly to the westward. About ten miles westward of the Palisade range and

concentric with it, occurs the First Newark Mountain, also a crescent or "canoe-shaped" ridge of trap. Scarcely half a mile westward of this is the Second Newark Mountain; and westward of this, again, is a fourth range of trap, much less regular than the others, and now appearing at the surface in detached areas. All these ridges slope to the westward at an average angle of 10—15 degrees, and present bold mural faces to the eastward, showing that they are outcropping edges of trap-sheets, that have been left in relief by the removal of the softer sedimentary beds that once inclosed them.

Quaternary Period.

There are no records in the rocks of Hudson County, belonging to the Cretaceous or Tertiary ages, which followed the Triassic; during that immense lapse of time, this region must have stood above the sea, and been clothed with the varied and beautiful floras that have now passed away, and inhabited by the strange reptiles of the Cretaceous and by many of the various animals that roamed over our country in the mild and beautiful Tertiary age. During the latter period, a climate as genial as that of Virginia extended nearly if not fully to the pole, and clothed the northern hemisphere with magnificent forests of temperate and sub-tropical growths. In the succeeding period, all this summer beauty was blotted out, and an age of ice succeeded, when the present climate of high latitudes, with immense snow-fields and glaciers, spread southward, until all the region from Central New Jersey northward was buried beneath a vast *mer de glace.* The records of this glacial age occur abundantly in Hudson County, and form one of the most marked chapters in its history.

The Drift.—Whenever the superficial material is removed from above the trap-rock in Hudson County, we invariably find the surface of the hard crystalline rock smoothed and polished, and all the projecting ledges worn and rounded off. This smoothed surface is also scratched and grooved in parallel lines bearing usually N. 10°—15° W. Upon this polished and striated surface rests an irregular, confused accumulation of earth and stones, from ten to twenty-five feet or more in thickness. This

sheet of drift is spread over all the highlands, and covering the hill-sides, dips beneath the more recent sand-dunes and salt-marshes along the Newark Bay on the west, and bordering the New York Bay on the east. This drift consists mainly of broken and disintegrated red sandstone and shale, derived from the Triassic area to the westward, and gives the prevailing reddish color to the soil. It also contains numerous boulders, frequently four or five feet in diameter; some of these are of trap, doubtless derived from the hill itself; others are of metamorphosed slate, the parent beds of which probably overlie the trap on the western slope of the hill; with these are mingled many masses of Triassic sandstone that could only have come from the region covered by that formation to the westward; there are also other erratics in less numbers, composed of gneiss, quartzyte, conglomerate, etc.,—rocks that are found in place only in the Highlands of New Jersey, at least thirty miles west. When these transported boulders are examined more closely, we find many of them worn and rounded, and like the trap beneath, showing *smoothed* and *scratched* surfaces. Although the drift covers nearly the whole of the county, yet it accumulated most abundantly along the eastern side of Bergen Hill, under the lee of the trap-ridge; for the glaciers came from the northwest. The boulders are also especially noticeable where the finer material has been carried away, either naturally or for purposes of improvement, as in some of the squares at Lafayette, in the Elysian Fields, etc. Another good exposure of the drift is to be seen along the line of the N. J. Central Railroad at Bergen Point; here the drift is overlaid by blown sand.

Over Hudson County, the glaciers were of great thickness, and flowed towards the southeast with such force that the trap-ridge of Bergen Hill could not deflect them from their course. The long parallel scratches and grooves on the rocks, as well as the nature of the transported boulders, show that the ice moved from the northwest obliquely across the ridge. Throughout Long Island, on the northern border of Staten Island, and in an irregular line of hills crossing New Jersey near Plainfield, is the terminal moraine deposited by these ancient glaciers.

To one familiar with existing glaciers, and the records that they leave on the rocks over which they move, nothing is easier

than to determine the former presence of glaciers on a grand scale in Hudson County. These glaciers retreated northward as this geological winter drew to a close, leaving behind the material that had been ground out and carried away from the underlying rocks; this *moraine profonde* covers nearly the whole surface formerly occupied by the glaciers. The material left by melting ice is unassorted, and seldom shows any stratification. But the melting of the glaciers caused floods, similar to those now occurring with the opening of spring, save on a far grander scale, which washed away large portions of this glaciated debris, and deposited it elsewhere, more or less perfectly assorted; the same end was also accomplished when the material was brought within the action of the waves and currents of the ocean or rivers. Examples of this modified drift, showing irregular layers of sand, gravel, and small boulders, all worn and rounded, may be seen on the western side of Bergen Hill near West End, and from there northerly along the western base of the hill. At several places in Jersey City near the Hudson, excavations have exposed sections of this stratified drift; these will receive farther notice in the section devoted to surface geology.

These beds in Hudson County yield a fine quality of building-sand, and also coarser sand and gravel, well adapted for making some kinds of mortars and concrete; the beds are always irregular, but sometimes of considerable importance. Among the economic uses of the drift, we should perhaps mention the abundant boulders, which furnish material suitable for the ruder kinds of masonry.

Æolian Sands.—All along the western border of Hudson County, where the upland meets the waters of Newark Bay, or the swamp-deposits extending some distance northward, there occur hills of fine, yellow, loamy sand, resting on the drift; from their structure, it is evident that these hills and mounds are true sand-dunes, formed of blown sand, that must have been piled up along the borders of the county before the accumulations of peat and mud now filling the swamps.

At Constable's Point, this fine yellowish sand covers nearly the entire hill, the highest part of which is about fifty feet above high tide; the central portion, however, is made up of drift

material with huge boulders, over which the sand has drifted. At Caven Point, a repetition of these conditions may be observed.

The upland, formed of glacial drift, containing quantities of transported boulders, on which Communipaw and Lafayette are situated, is covered to a large extent with similar sand.

The islands formerly known as Paulus Hook, Harsimus, and Pavonia, on which the older portion of Jersey City is built, have the same history as these other areas of æolian sand.

Around the high land forming Castle Point, similar accumulations of glacial drift covered with blown sand may be seen; the sandy region here underlies a large portion of Hoboken.

Swamp Deposits.—The series of geological formations in Hudson County is brought to a close by the salt meadows bordering the county on the east and west, and still in process of accumulation. These are formed of vegetable growths, making a peaty mass, composed of matted stems and roots at the top, but becoming more compact and showing less vegetable structure at some distance below the surface; the peat is frequently rendered impure by silt and mud brought in by high tides, and in places these muddy sediments predominate over the vegetable matter, and form a great depth of blue clay or mud.

Surface Geology.

Soils may be divided according to the mode of their formation, into soils of *disintegration* and soils of *transportation*. The former are derived from the wearing away of the rocks upon which they rest, and owe their formation to the fact that even the most compact and homogenous rocks, when subjected to meteoric agencies, are in time broken up and more or less decomposed. Disintegrated rock of this nature, with some admixture of organic matter or humus, forms the soil over a large part of New Jersey. Soils of transportation, on the other hand, have resulted from the accumulation of material brought from distant sources, and are influenced but little by the nature of the underlying rock. As examples of soils of transportation, we have river drifts, consisting of sand, gravel, alluvium, etc.; and also the earth, clay and sand filling lake-basins and estu-

aries ; and blown sand occurring in sand-dunes : more common than any of these, however, are the soils formed of glacial drift; this may vary widely in its nature, being sometimes sand, gravel, clay, shingle, etc., or these in all degrees of admixture. Besides these kinds, there are other soils formed of peat and bog earths, that are due mainly to organic agencies.

The soils occurring in Hudson County are formed entirely of transported material, together with accumulations of peat and mud;—soils resulting from the disintegration of the underlying rocks being unrepresented. The soils of the county thus group themselves into four natural divisions according to their mode of origin ; these at times are more or less intermingled, but are usually well characterized and easily distinguishable; they are, in the order of their age, as follows :

1st. Soils composed of glacial drift.
2d. " " " stratified drift.
3d. " " " æolian sand.
4th. " " " peat and mud (now forming).

1. *Soils of Glacial Drift.*—These consist of the material that was left spread over the country by the retreating glaciers, viz. sand and clay, derived mainly from the grinding and disintegration of the Triassic sandstones and shales. From the same source have these soils acquired their characteristic reddish color, due to the peroxide of iron they contain. Mingled with this reddish-clayey soil, are great numbers of stones and boulders, often of large size, and mainly transported from the westward. This soil is quite constant in its composition, when unmodified by cultivation, drainage etc.; is rather stiff, owing to the amount of clay it contains; and is retentive of moisture. By its color and unstratified condition, it may be readily identified.

This soil occurs covering the high ridge bordering Hudson County along the Passaic; eastward of this, it appears again around Snake Hill, and forms the surface of the upland known as Secaucus, northward of Snake Hill. South of Snake Hill, and between the Passaic and Hackensack Rivers, the boulders of the drift were struck at a depth of 125 feet, in the sinking of wells.*

* Vide Table No. 1 at the end of this article.

Nearly the whole of the main upland of Hudson County, from the Kill Von Kull to Bull's Ferry road, is covered with glacial drift soil. Its characteristic features are well shown at Bergen Point, along the line of the N. J. Central Railroad, and at the railroad cuts and street excavations in various parts of Bergen Hill and Weehawken: the depth of the drift in these exposures varies from a few inches to twenty or thirty feet.

Eastward of Bergen Hill, the glacial drift soil occurs at Constable's Point, Caven Point, Communipaw, and Lafayette; also on the islands on which the older portion of Jersey City is built, viz. Paulus Hook, Harsimus, and Pavonia, and on the similar area northward of these around the serpentine hill forming Castle Point. At all these localities the reddish glacial drift, with its boulders, etc., is largely covered by blown sand, which forms our third division of soils.

The amount of clay which these soils contain makes them less retentive of moisture, and therefore less desirable from a sanitary point of view, than more sandy and porous strata. This tendency to retain the surface water is counteracted in some portions of Hudson County by the slope of the underlying rocks, which secures a good natural drainage.

This is the case on the western slope of Bergen Hill, and also on some portions of Bergen Neck and Bergen Point, where the drainage is to the eastward. Over a large area on the top of Bergen Hill, however, where the trap-rock has been worn down by glacial action to an irregular plane surface, the covering of drift fills the depressions in the rocky floor beneath, and thus forms a soil, not only stiff and retentive, but also with an incomplete or in many cases total lack of drainage; this region, I understand, has long been known to resident physicians as one where malarial diseases particularly prevail. In some cases, wells have been sunk through the covering of drift on Bergen Hill, and a supply of water obtained from some of these concealed sink-holes, thus greatly endangering the health of those using the water. In West Hoboken and Weehawken, several of these depressions in the trap—some of them receiving the drainage from considerable areas—may be seen; they are now in the condition of lakelets or marshes filled with decaying vegetable matter, which become partially dried in the summer, and cer-

tainly have anything but a beneficial influence on the health of the community.

On the western side of the hill, and reaching sometimes nearly to the top of the slope, the soil is usually more sandy; but this is often a deceptive appearance, as the sand is a superficial covering concealing the reddish glacial drift soil but a few inches below. Most of this region, however, has a natural drainage, which secures for it a greater salubrity than the irregular plain on the top of the hill enjoys.

Soils of Stratified Drift.—The material left by the melting glaciers, when brought within the action of tides and currents, was assorted and more or less stratified, so as to form irregular and rapidly alternating accumulations of clay, sand, gravel, boulders, etc. Soils of this kind occur at many localities westward of Bergen Hill, near the junction of the upland with the salt marshes and Newark Bay. These deposits have been excavated to obtain sand and gravel in the level areas in the neighborhood of New Durham, west of Weehawken, and at several points near West End, and may be recognized, although usually covered with sand-dunes, at a few localities farther south along Newark Bay.

East of Bergen Hill, the best example of modified drift exposed in Hudson County is to be seen in the knoll north of Communipaw, near the southern end of Mill Creek. This hill has been cut away on the eastern side, to obtain building-sand and gravel, and exhibits a fine section of a "kame," as these knolls of modified drift are called. The varying strata of clay, sand, gravel and boulders, here exposed, are very irregular and frequently show the oblique lamination known as "current bedding;" the strata are frequently wedge-shaped or truncated, having been eroded by the currents that deposited the next succeeding layer. These irregular beds vary from a fraction of an inch up to three or four feet in thickness, and were evidently deposited in strong and frequently changing currents. This hill is plainly the remnant of a great deposit of drift which at one time probably filled the valley or cañon of the Hudson.

Portions of Harsimus, Pavonia and Hoboken are also underlaid by modified drift, but in this region the contour of the land

and the nature of the original soil have been so modified and obscured by streets and buildings, that their original character cannot be determined.

The greater part, indeed, of Harsimus and Pavonia seems to have been underlaid by modified drift, most of which was concealed by hills of fine yellowish æolian sand.

The northern portion of Pavonia, judging from the limited exposures now to be seen, is composed of true glacial drift.

Whenever the soil consists of modified drift, at least when moderately elevated, it forms a porous and highly salubrious substratum.

Soils of Æolian Sand.—The fine, yellowish, loamy sand already noticed, forms the third division of soils in Hudson County. Along the Newark meadows and Newark Bay, the sand-dunes sometimes extend a long distance inland; on Bergen Neck, the sand covers nearly half the breadth of the upland; at Bergen Point, it is well exposed along the railroad, overlying the reddish drift, and thinning out gradually as it recedes from Newark Bay.

At Constable's Hook, this yellowish sand occurs again, covering nearly the entire upland; this detached area, separated from Bergen Point by a deep marsh, covers about 200 acres, with an elevation of from 40 to 50 feet, and consists chiefly of glacial drift containing huge boulders, above which rest the æolian sands. There is very likely a reef of rock underneath this island-like area, yet none appears at the surface, or has been reached in a well bored on the southeastern side of the Hook, to a depth of 130 feet. On the sand-dunes, forming the western side of Constable's Hook, are growing oak, chestnut and beech trees, frequently of large size. The soil on this area is light and porous, and well adapted for the requirements of the large manufacturing industries located there.

At Caven Point, the conditions are the same; and also, as above stated, on the areas farther north, now occupied by Lafayette, Jersey City and Hoboken. At Lafayette, the æolian sands are well shown on the western side of the high knoll at the end of Mill Creek. The sand-hills of Harsimus and Pavonia, most of which have now been leveled, were similar.

The geological history of the island-like areas that rise above

the salt-marshes eastward of Bergen Hill, is well illustrated by by Paulus Hook, Harsimus and Pavonia. Beneath this region, especially along its eastern margin, are the reefs of gneiss that at one time formed low islands separated from Bergen Hill by a deep river-channel; around this nucleus the debris transported from the west by the glaciers, was accumulated and probably filled deeply if not completely the channel of the river. When the glaciers retreated, and the floods from the melting ice came down the Hudson, much of this material was removed, some to distant places and other portions re-deposited as stratified drift. At this time the old channel between Bergen Hill and Paulus Hook was re-excavated, and the Hudson flowed to the sea with a greater flood than at present, having Bergen Hill for its western shore. This western portion was not a main channel, however, as it rejoined the principal stream at the mouth of Mill Creek, and did not flow over the upland area now occupied by Lafayette. While the waters flowed through this course, the sand along the shore was thrown on the beach and was carried inland by the wind, forming sand-dunes spread over the drift beneath. In time, as the Hudson decreased in volume, the western channel was silted up with river mud so as to form salt meadows on which grasses and swamp-loving plants took root and formed by their decay the peat and peat-mud.

Soils of Peat and Mud.—Skirting the main upland of Hudson County on the west, are the salt marshes known as the Newark Meadows; these were formed by the filling in of this portion of the estuary of Newark Bay by silt and mud brought in by the waters. The depth of this accumulation is from ten to fifteen or perhaps twenty feet; the true rock-bottom, however, lies far below, as is shown by the deep wells in the meadows south of Snake Hill.* In some of these, no rock was reached at a depth of 200 feet; north of Snake Hill the surface of the peat and mud was once covered with a vigorous growth of cedar trees, the stumps and prostrate trunks of which now cover the marsh.

On the eastern side of Bergen Hill, the salt meadows again

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* Vide Table No. 1.

occur. Constable's Hook is separated from Bergen Point by the southernmost of these areas. Here, in some portions of the Newark Meadows, the surface consists of peat formed of the matted stems and roots of plants, which become more decomposed and muck-like some feet below.

The salt-marsh occurs again southward of Lafayette, filling the arëa between Caven Point and Bergen Hill. Northward of Lafayette, and reaching all the way to the Hudson above Castle Point, is the largest area of salt-meadow east of Bergen Hill. It is like the others already mentioned, in character.

Along the Morris Canal, between Lafayette and Harsimus, soundings have been made in the marsh to the depth of 90 to 130 feet without reaching rock-bottom. In one of these soundings near the canal bridge on Pacific Avenue, a stream of quicksand is reported, at the depth of 130 feet, flowing southward with such force as to bend the sounding-tube.

On the western edge of the upland forming Harsimus, near the corner of Wayne and Brunswick Streets, a large well has recently been excavated, giving the following section :—

Filling, - - - - -	10—12	feet.
Turf (the original surface of the marsh),	2	"
Bluish river-mud, with oyster-shells, pine-cones, drift-wood, etc., - - -	12—14	"
Quicksand, - - - - -	6	inches.
Reddish mud, - - - -	18	feet.
Gravel, - - - - -	5	"

On the eastern side of the block in which this section was obtained, and commencing less than 100 feet away, is the remnant of a hill of sand and gravel, which still rises some twenty feet above the surface of the marsh, showing the abrupt nature of the shores of the old river-channel that once divided Harsimus from Bergen Hill. The same thing is illustrated at the corner of Washington and Warren Streets, where less than four hundred feet from the upland, piles have been driven through peaty mud to the depth of over seventy feet, to form the foundation of St. Peter's church. Other instances might be mentioned, showing that the deposits of drift and sand east of Bergen Hill

have been deeply eroded by currents of water, the channels of which have since been filled in with mud and peat ; the islands known as Paulus Hook, Harsimus, and Pavonia, are separated from each other and from Communipaw, Bergen Hill and Hoboken by deep-buried channels of this nature.

The Sanitary Influence of the Soils of Hudson County.—The salubrity of a region depends largely on the pervious or impervious nature of the soil ; the lowering of the consumption death-rate especially, is closely connected with the decrease of water (especially fresh water) in the subsoil. In Salisbury, England, the death-rate from consumption has been lowered one-half by improved drainage. The following conclusions on this important subject are taken from an article by W. Whitaker, in the Geological Magazine for November, 1869.

(1) That on pervious soils there is less consumption than on impervious soils.

(2) That on high-lying pervious soils there is less consumption than on flat pervious soils.

(3) That on sloping impervious soils, there is less consumption than on flat impervious soils.

(4) Wetness of soils is the great cause of consumption.

With these considerations in mind, I have arranged the soils of Hudson County as follows, referring especially to their pervious or impervious character. When considered geographically, the conditions of elevation, drainage, etc., come in, and greatly modify these general laws when applied to limited areas.

First.—The most desirable soils, from a sanitary point of view, are those formed of modified drift, composed of strata of sand, gravel and boulders.

Second.—The second best soils are those composed of the fine yellowish loamy sand frequently mentioned on the preceding pages.

Third.—Next in the series comes the soil formed of reddish drift, which covers so large an area in Hudson County; if well drained, this soil has but few objectionable features ; these increase rapidly, however, as drainage is obstructed. When underlaid by a porous and elevated rocky substratum, as at Castle

Point, no more salubrious soil could be desired. The conclusion naturally follows, that in order to make the 11,000 acres of retentive and badly drained soil on the top of Bergen Hill, where upwards of 60,000 people have their homes, as salubrious and desirable for a city, as the identical soil occurring at Castle Point, the proper course is to secure a more complete drainage.

Fourth.—In this class we place the salt marshes, for even these, owing to the rapid increase of population, are built upon; sometimes the marsh is filled in with garbage containing decaying organic substances, which for a long time at least must render such artificial soils unhealthy.

Conclusion.

The salt marshes form the last of the series of geological formations occurring in this county; these are still in process of accumulation, and form the top of the grouped section of the rocks of Hudson County, (Plate II).

Prof. Cook in the "Geology of New Jersey," 1868, presents many interesting facts indicating that a slow subsidence of the land is now in progress along the Atlantic border of New Jersey.

As I have been unable to glean any new facts in relation to this subject in Hudson County, I can only refer the reader to the above report for information in this regard.

At many places on the knolls along Newark and New York Bays, accumulations of oyster-shells may be observed: these at first sight might lead to the conclusion that the land had suffered a subsidence and a re-elevation in very recent times. These shell-heaps, however, are due to other causes, and in some cases at least, were accumulated by the aborigines, before the coming of the Europeans. On the knoll at the mouth of Mill Creek northeast of Lafayette, one of these accumulations of oyster-shells or *"kjokken-möddings,"* may be seen; with the broken oyster-shells, a foot below the surface, I found the shells of land-snails; the occurrence of stone implements and human bones in the same association was reported by the gardeners familiar with the locality. At Constable's Hook and along the shore of Newark Bay, similar shell-heaps are very common.

Erosion and Denudation.—From the table at the end of this article, showing the depth of wells and of soundings in the salt

meadows that have reached the underlying rock, we are enabled in a general way to sketch the topography of Hudson County as it would appear if the accumulation of superficial material were removed. A map or model constructed from such data would enable us to determine the depth to which river-channels have been eroded and also aid us in calculating the amount of denudation that the general surface of the county has suffered.

From the wells bored in the estuary of Newark Bay, now to a great extent occupied by salt marshes, we find that the rock in some places is more than two hundred feet below the surface of the marsh. At Hackensack, 18 miles north of the present outlet of the bay, the rock is 104 feet below the surface.

Although no soundings have been obtained from the southern end of the bay, yet it is fair to assume that here is the greatest depth, probably not less than 300 feet. As the surface of the marsh is 150 or 200 feet below the present level of Bergen Hill, and nearly as much lower than the ridge of Triassic rocks bound- it on the west, the total depth that the valley of the Hackensack has been excavated cannot be less than between 350 and 500 feet.

To calculate the amount of sandstone and shale that has been removed to form the estuary from Hackensack southward, we have only to compute the contents of a solid 18 miles long, 4 miles wide, and 350 to 500 feet thick; this will give, taking the lowest average of thickness, about 77 cubic miles as the amount of material removed.

At one point between Jersey City and Lafayette—east of Bergen Hill—soundings to the depth of 130 feet failed to reach the bed-rock. The reef of serpentine at Long Dock, Jersey City, is buried to the depth of 179 feet. The following borings, some of them reaching to the bed-rock, are taken from the table at the end of this essay; excepting those in the Harlem River, they are all on the margins of the old channels and do not show their real depth:—

Hudson River, foot of 23d St., 250 ft. from the eastern building line of the river street,	175	ft. to rock.
Hudson River, foot of Bethune St., line of the river street,	196	" rock not reached.
Hudson River, pier 60 (old No.), 20 ft. W. of bulkhead line,	175	" to bed-rock.

East River,	N. Y. Tower of Brooklyn Bridge,	107.4 ft. to bed-rock.	
"	Brooklyn Tower, " "	88 "	"
"	pier 41, N. Y., 200 feet from the building line of South St., -	91 "	"
"	pier 18, " "	60 "	"
Harlem River at High Bridge, center of river,		70 "	"
"	Madison Av. Bridge, " "	75 "	"

As shown on the Coast Survey charts of New York harbor, the water in the Hudson off Castle Point is - 50— 65 ft. deep.

In the East River, W. of Blackwell's Island,		107	"	"
"	" at Hell Gate, - -	121	"	"
"	" Ward's Island, -	170	"	"
"	New York Harbor, - - -	60— 80	"	"
"	the Narrows, - - - - -	60—116	"	"
"	the Kill Von Kull, - - -	25— 54	"	"
"	Arthur's Kill, - - - - -	20— 35	"	"

These soundings give the present depth of the water; how much the old channels have been filled with drift and silt is unknown. All this shows, as has been graphically described by Prof. J. S. Newberry,* that these channels are old river-beds, eroded when the continent stood at least 500 feet above its present level.

The true margin of the continent lies at a distance of 80 miles outside of the present mouth of the Hudson; over this region, once a broad littoral plain, the Hudson flowed after passing New York and Staten Island. The position of this submerged river-bed is shown on the Coast Survey charts by the line of deep soundings extending seaward from New York harbor. During this time of continental elevation, previous to the glacial period, the deep cañon-like valley of the Hudson was excavated, and also a great part of the broad, deep valleys of the Hackensack and Passaic; these streams perhaps, after uniting, flowed through Arthur's Kill and received the Raritan as a tributary.

As we have already seen, there is no evidence that Hudson County has been submerged since the close of the Triassic age; during all the vast time recorded in other regions by the deposits

* The Geol. Hist. of New York Island. Popular Science Monthly, 1878.

of the Cretaceous and Tertiary ages, Hudson County stood above the sea and was exposed to sub-aerial denudation, and also felt the full force of the cold and ice of the Glacial epoch. However slowly the wind, rain and frost may act in degrading rocks, yet we know that during the flight of ages they accomplish mighty results; what these changes were in this region we of course desire to know. The only way to determine the amount of material removed from the general surface of Hudson County, is by studying the character and position of the rocks that remain. As we have already seen, the most remarkable fact in connection with the Triassic rocks in New Jersey is the uniformity of their dip to the northwestward; from the nature of the excavation that produced Newark Bay, leaving a ridge on the western side 150 feet high, composed of stratified rocks inclined 15° N. W., it is evident that larger portions of the sandstone and shale have been removed, than are necessary to fill the valley. Considering this county alone, if we carry out the strata to the position which their dip and broken edges, indicate that they once occupied, we find that the thickness of sandstone and shale once covering Bergen Hill could not have been less than 7,000 or 8,000 feet. If no faults exist in this region, we cannot arrive at any other conclusion than that many thousands of feet of stratified rock have been removed from the general surface of the county.

Drainage and Reclamation of Land.—Geology has but little to do with agriculture in Hudson County; but on all questions as to the reclamation of land, building of piers, construction of railroads, etc., it has a direct and important bearing.

In other countries, immense areas have been reclaimed from the sea by diking; this same process has been followed in some portions of New Jersey with marked success. In Hudson County, however, little has been done in this direction; some portions of the Newark Meadows have been thus reclaimed, but no very promising results have followed. One reason for the lack of success is the nature of the swamp-deposits, which consist of undecomposed vegetable matter to so great a depth that they are useless for agricultural purposes.

The most important reclaimed areas are along the Hudson; here the plan has been to fill in the swamps up to a level above

tide. Knowing the nature of these old channels, and their great depth, this is evidently a most laborious and expensive undertaking. The want of some comprehensive plan both for the drainage of the upland and for the reclamation of the salt meadows and shallow areas along New York Bay, has long been felt; thus far this work has been carried on without system, and consequently much of it is ineffectual. A plan which meets all the requirements of the case, and is based directly on the geological structure of the county, was proposed some years since by Mr. L. B. Ward, C. E., of Jersey City.

The reef of Archæan rocks which appears at Hoboken, and again along the eastern edge of Jersey City, extends southward along the line marked out by Ellis's, Bedloe's, Oyster and Robbins's Reef islands; then it curves westward to meet Constable's Hook. West of this line of reefs, the water is shallow, as shown on the Coast Survey charts. In some places, the rocky bottom is exposed at low tide. Directly east of the same line, the bottom falls away sharply, and forms the true cañon-like channel of the Hudson, with from twenty to sixty feet of water.

The plan proposed is to complete the work marked out by nature, and by building a sea-wall along the old reef, from Jersey City to Constable's Hook, to shut out the tide, and by means of pumps, as is now done for a large part of London, to remove the water from the inclosed area, and thus render it suitable for occupation. The drainage of the marshes west of Jersey City and Hoboken, and the interception of the surface water and drainage from Bergen Hill, are to be secured by a large sewer built along the base of the hill, and leading into the lower part of the area reclaimed.

This comprehensive plan, which we are only able to sketch in the barest outline, has for its object not only the addition of 5,100 acres to the habitable area of Hudson County, and that, too, where space is most needed, but also, what is still more valuable, the proper drainage of large areas now densely inhabited. Such a plan, if carried out, will secure for the county an addition of several miles of piers to her already crowded water-front, and furnish over five thousand acres for railroad depots, storehouses, manufactories, etc.

TABLE SHOWING DEPTH OF WELLS AND SOUNDINGS IN HUDSON CO., N. J.

No.	LOCATION.	TOTAL DEPTH.	DEPTH TO ROCK.	MATERIAL ABOVE THE ROCK.	CHARACTER OF THE ROCK.	REMARKS.
		Feet.	Feet.			
1	In the marsh near west end of "Hackensack Bridge," on Newark and Jersey City turnpike. On Newark marsh.	100	100	Through sand, gravel, hard-pan, and clay.	Well touched red sandstone and the boring was stopped.	Well bored for Anthony Dye previous to 1832. Diam. 6 in.; water rose nearly to the surface and continued good as long as used; not used for 35 years. Disbrow & Sullivan's pamphlet, ("Advertisement for a Proposition for Ward Companies to supply N. Y. City with Rock Water.")
2	About 1,000 ft. S. W. of No. 1, and 200 ft. S. of N. J. R. R. On Newark marsh.	100	100	"	"	Well 4 in. diam.; water good and abundant; now abandoned. *Ibid.*
3	At the "Mosquito Tavern," junction of Belleville and Newark turnpikes. On Newark marsh.	104	104	Marsh mud and roots, ft. 10 Quicksand, fine, 12 Bluish-gray clay, 36 Sand, 6 Ash-col'd clay, 20 Stiff variegated clay, 20	"	Bored about 1826 for the "Grazing Company," by Mr. Drewery, who reported it to be 200 ft. deep without reaching rock. Excellent water rose nearly to the surface, and was also obtained at the depth of 84 ft. Mather's Report on Geol. of N. Y., p. 18. Also, Silliman's Jour. Vol. 12, (1827) p. 139.
4	About one mile W. of No. 3, on the S. side of Newark turnpike, on Newark meadows.	80	—	In swamp deposits.	"	Bored for S. Swartwout, Esq. Well overflowing. Disbrow & Sullivan.
5	About one mile W. of No. 4, near the Newark turnpike.			"	Ended in red sandstone.	Disbrow & Sullivan.

6	On the estate of S. N. Pike, Newark plank road, about 1,000 ft. W. of Hackensack bridge.	180	Not reached.	At 180 ft. passed through rock 2 ft. thick (boulder?), and reached water-bearing gravel		Wells Nos. 6, 7, 8, and 9 were bored in 1871. No. 6 is 6 in. diam., the rest 2 in. Loose red shale was found in all these borings from time to time, and boulders were passed through at the depth of 125 ft. Statement by Mr. M. S. Toohey.
7	Same estate as No. 6.	185	"	At 180 ft. passed through 6 in. pale sandy rock, and then reached water-bearing gravel, as in No. 7.		
8	Same estate as Nos. 6 and 7.	190	"	Water obtained as in Nos. 6 and 7.		Water sweet, palatable, and abundant. Statement by Mr. Toohey.
9	Same estate as Nos. 6, 7 and 8, 3,000 feet W. of Hackensack R., midway between Newark plank road and Penn. R. R.	195	"	"		
10	At Dey's Poudrette Works, near the Hackensack.	125	"	Boring stopped by boulders.		Three attempts were made here about 1873 to bore a well, but they were abandoned at about 125 ft. Statement by Messrs. Dey and Toohey.
11	Near the Erie R. R., at the junction of Berry's Creek with Hackensack R.	90	90			A well is reported as sunk here reaching rock at 90 ft.; no other details.
12	Soundings across the Hackensack river on a line 200 ft. S. of the Penn. R. R bridge, 100 ft. apart. No. 1 on E. bank of the river.	54 to 75			Rock not reached.	(see soundings below)

	High water to mud	High water to clay.	High water to hard bottom.
1	6.2	33.7	24.1
2	27.	46.8	56.4
3	35.6	54.8	64.9
4	37.9	45.4—62.4	69.3
5	37.6	64.2	68.4
6	35.5	53.8—63.0	72.9
7	34.0	71.4	75.0
8	83.3	57.1	73.0

						9 32.4 47.7 57.3 10 26.2 52.3 61.7 11 24.0 46.4 65.3 12 13.2 45.2 69.7 13 3.5 43.5 61.9 Information from Mr. J. T. Richards.
13	Penn. R. R. workshops, Hackensack meadows.	17		Meadow soil ft. 11.0 Fine sand, 1.5 Coarse sand, 1.5 Blue clay, 3.0	Not reached.	The piles for the foundation of the shops are driven down to the coarse sand, and furnished a firm support. Mr. J. T. Richards.
14	Soundings along the Harsimus branch of the Penn R. R. in Jersey City.	12 to 112			No rock reached at these points.	1 100 ft. E. of J. C. Cemetery, 50 ft. 2 Midway bet. 1 and 3, 112 3 At Newark Ave, 60 4 " Brunswick St, 45 5 " Monmouth St., 25 6 " Cole St., 15 7 " Jersey Ave., 15 8 " Henderson St., 12 Information furnished by Mr. Sandford Ross.
15	At the Secaucus Iron Works, between Hackensack river and the upland of Secaucus.	600	18		Down to red shale rock, ft. 18 Red shale, 252 Shaly sandstone, 25 ——— 5 Red shaly sandstone, 200	Well still in process of construction. Geol. Rept. of N J., for 1879, p. 129.
16	Near the Newark bay shore at the end of Waverly St., J. C.	36 to 49	36 to 49	Yel. dune sand $1\frac{1}{2}$-8 Sand and gravel, water-bearing, 4-6 Bluish sandy clay, 1 Sand and gravel, quicksand at bottom, 15-16	Trap rock reached.	Twenty five driven wells were put down near this locality by Mathiesen & Wiechers, in 1877. The ground is from 10 to 20 ft. above tide level. Geol. Rept. of N. J. for 1879, p. 150.

				Reddish sandy clay, including some gravel, and very sandy at the bottom, 15-18 Trap-rock at bottom		
17	At Huyler & Rutan's dock, Hackensack, Bergen Co.	105½	104	Meadow mud, 10-12 Blue clay with seams of red clay, 92-94 Shale, 6 in. (The drill dropped 6 in.) 6 in. Shale, 7 in.	Red shale penetrated 1 ft. and 7 in.	*Ibid.*, p. 128.
18	In Hudson St., J. C., bet. Morris and Essex.	250	24	Drift material.	Penetrated through gneiss 150 ft.	Silliman's Jour., Vol. 12 (1827), p. 139. Disbrow & Sullivan.
19	At Harsimus, probably where Cox's brewery now stands, on Grove St., bet 7th and 8th Sts., J. C.	60	Not reached.	In sand, gravel and hard-pan.		Probably carried on as given for No. 23. Begun in June, 1825, in a well 30 ft. deep. Surface of ground about 18 ft. above tide. Silliman's Jour., Vol. 12 (1827), p. 139.
20	In marsh near the S. end of Grand St., Hoboken.	400	40		"Serpentine, sandstone and supposed white marble," but apparently bored principally in serpentine.	Mather's Rep. Geol. of N. Y., p. 603. L. B. Ward's Rep. Geol. Surv. of N. J., 1879, p. 130. Mr. Drewery, who bored the well, between 1828–'33, states that "it was 400 ft. deep, 18 ft. in earth, and the remainder in sandstone; water, mineral and overflowing."
21	At Matthiesen & Wiechers' sugar factory, foot of Washington St., on the S. side of the Morris canal, J. C.	1000	20	"Surface earth."	The rock penetrated was chiefly gneiss and quartz with white sandstone and thin	Well bored in 1872. Diam. of upper 180 ft. 8 in., the rest 4 in. Several veins of water were struck between 600 and 900 ft.; the most important at 720 ft. The yield was 50 gallons

					bands of slate, occurring below 800 ft. A few feet of rock at the surface said to be serpentine.	per minute, when tested by pumping. Level of water in the well 12 ft. below tide. Temperature 52° F. The water was brackish, which prevented its use; well now closed, Ward's Rep., Geol. Surv. N. J., 1879, p. 130.
22	In the marsh, corner of Montgomery and Henderson Streets, J. C.	215	15		Red sandstone penetrated for 200 ft. ended in whitish sandstone.	A small boring was made here in 1842 by Andw. Clark; clear, bright water obtained freely at 150 ft., but strongly impregnated with magnesia and common salt. Ward's Rep., p. 131.
23	At Cox's brewery on Grove Street, between 7th and 8th Streets, J. C.	400	70	Boulder clay.	"Hard dark sandstone, growing more like the ordinary brown-stone towards the bottom."	Small veins of water were met with in the rock at all depths. The water though so hard as to form a heavy scale in a steam-boiler, was satisfactory for brewing purposes. Temperature 54° F. This well of 5 in. diam., affords 300 bbls. per day. The water rises to tide-level. Appears to be a continuation of the well bored by Levi Disbrow in 1822 (No. 19). Ward's Rep., p. 131.
24	At Lembech & Betz's brewery, 9th St., between Grove and Henderson Sts., J. C.. ANALYSIS OF THE WATER. Grs. per gall. Soda, 39.50; Lime, 6.95; Magnesia, 9.36; Sulph. acid, 4.11; Chlorine, 65.50; 125.42	846½	70	Surface sand, ft. 30 Boulder clay, 40	Red sandstone rock.	A boring 8 in. in diameter was made here in 1875, 846½ ft. The water is sufficiently soft and sweet for brewing, but is ordinarily used only for cooling purposes. Water obtained from a coarse gravely stratum, about 20 ft. from bottom. Temperature 52½ F. Yields 1000 bbls. per day. Level of the well 10 ft. below tide; 25 ft. below surface of the ground. *Ibid.*

25	At the Pavonia Ferry, J. C., three borings were made at distances respectively of 2300, 2850 and 3300 ft. nearly E. from No. 24.	63 120 179	63 120 179		Came upon serpentine at the bottom.	Ward's Report.
26	At the Palisade brewery, on Bergen Hill, cor. Hudson Ave. and Weehawken St.	297	16	Glacial drift.	Through trap rock.	Diam., 7 in.; bored in 1877—78. The well is pumped from the bottom, and yields 250 bbls. per day. Temp., 51° F. Ward's Report.
27	Tunnel under the Hudson River, foot 15th St., J. C.	124		Bluish river-mud with shells.		Greatest depth reached in sounding was 124 ft., at 1000 ft. from the N. J. shore. About 1000 ft. from the N. Y. shore, a reef of rock reaches to within 89 ft. of the surface. The shaft on the J. C. side is 60 ft. deep through mud. Rock not reached save at the locality just mentioned. Information furnished by C. P. Brush, C. E.
28	In the salt marsh W. of Hoboken, on a line with 12th and 15th Sts.	80		Bluish-black mud.		A number of soundings were made; hard bottom not reached at 80 ft. C. P. Brush, C. E.
29	In Harsimus Cove, J. C., 1450 ft. E. of the W. side of Green St., on a line produced half way between 2d and 3d Sts.	160			Rock not reached.	Information furnished by J. T. Richard, C. E.
30	In Harsimus Cove, 300 ft. S. of the produced line of No. 29, and 1100 ft. E. of the W. side of Green St.				" "	Information furnished by J. T. Richard, C. E.

TABLE SHOWING DEPTH OF WELLS AND SOUNDINGS IN AND AROUND NEW YORK CITY.

No.	LOCATION.	TOTAL DEPTH.	DEPTH TO ROCK.	MATERIAL ABOVE THE ROCK.	CHARACTER OF THE ROCK.	REMARKS.
		Feet.	Feet.			
31	Near Trinity Church;—"the old rock well."	26				Surface 35 ft. above tide; supposed to have reached rock. Mather's Rep. Geol., 1st Dist., N. Y., 1843, p. 603.
32	College Place.		90	All sand.		Surface about 18 ft. above tide. *Ibid.*
33	Washington St., bet. Fulton and Vesey Sts.	70	70			Surface 8 ft. above tide. *Ibid.*
34	Cor. Bleecker St. and Broadway.	448	42	Through earth.		Surface 36 ft. above tide. Water of 52° F. rose to within 29 ft. of surface. Information furnished by Mr. Drewery. *Ibid.*
35	Cor. Factory and Perry Sts.	200	70			Surface 24 ft. above tide. *Ibid.*
36	At City Reservoir in 13th St.	113	15			*Ibid.*
37	16th St., near the Hudson.	120	20			Surface 23 ft. above tide. *Ibid.*
38	26th St. and 10th Ave., brewery of Flanagan & Wallace.	350	79	Sand and Gravel.		Unfinished, now being bored. Information by Mr. Button.
39	47th St. and Hudson R., Symond & Co.	402			Granite, gneiss and mica-schist.	Clear water rose in the bore at 40 ft., but insufficient. When water-course was tapped, the water rose very freely, but emitted a sickening odor, and became covered, on standing, with oily films. Odor lessened after long pumping. Temp., 52°—56° F. Yield 4000 bbls. per day. Information from Mr. L. P. Gratacap.
40	Fifth Avenue Hotel.	1108			Gneiss.	Water not reached, to May, 1880.
41	Under United States Hotel,	626	126			Mr. G. W. Drewery reports this well as 900 ft. deep, with a good supply

	"Holt's" well, bet. Pearl and Water Sts.					of brackish water obtained from the bottom. Mather's Rep. p. 603.
42	At Fulton Market.	130				Surface, 8 ft. above tide. *Ibid.* p. 604.
43	At the old City Hotel, cor. Water and Fulton Sts.	$92\frac{2}{3}$	$92\frac{2}{3}$		Reaching bed-rock.	Information from F. Collingwood, C. E.
44	Brooklyn Bridge. Anchorage in Brooklyn, 930 to 1060 ft. from the river.	145 below tide.		Boulder clay, with clay and sand.	Stopped by rock or a large boulder.	The excavation here was 45 ft. below tide ; the boring penetrated 100 ft. further, until stopped. The boulders here were of gneiss, trap, etc., often rough and angular, and from 10 to 20 tons in weight.
45	Brooklyn Bridge, borings for the foundation of the N.Y. tower, Sept. 10th–23d, 1877.	114	107–6	Alternations of sand and mud with some clay and gravel.	Mica schist penetrated to the depth of 6.4 ft.	Information furnished by Department of Docks, N. Y. C. The rock on which the pier-foundations rest is gneiss, with a very irregular surface; in a space 172x100 ft. the depth below high tide varied from 75 to 94 ft. The caisson was stopped at 78 ft. Maximum depth of water bet. the N.Y. and Brooklyn piers was 60 ft. Information by F. Collingwood, C. E.
46	Brooklyn Bridge: boring for the foundation of the Brooklyn tower.	88	88	Sand, gravel, clay, and boulders.	Mica schist.	Information furnished by Department of Docks, N. Y. C.
47	At the N. Y. Anchorage ; on the old shore line, (now Water St.)	50		Borings carried to 50 ft. showed only sand and gravel.		Along the N. Y. approach, excavations have been made to a depth of 11 ft. below tide, through mud, clay and clean sand. Information by F. Collingwood, C. E.
48	In lot next N. E. of Harper's building, (bet. Ferry, Cliff, Frankfort and Pearl Sts., N.Y.)	116–5	116–5	Sand, clay and gravel.	Penetrated to rock, 92.5 below high tide.	Information furnished by F. Collingwood, C. E.

49	Centre St., Halls of Justice.	100		Filling, ft. 40 Black mud, 30 Blue clay, 30		Surface 8 ft. above tide. Mather's Report, p. 604.
50	Duane St., near Centre.	30				Known as the "Manhattan Well," dug in 1799. *Ibid.* p. 603.
51	At No. 118 Elm St.	130	130			Surface 11 ft. above tide.
52	Cor. Grand and Wooster Sts.	72		Filling, ft. 40 Mud with trees and vegetable matter, 20 Fine blue clay, 6 Sand, 6		In an old swamp, 8 ft. above tide. Mather's Report, p. 603.
53	Allaire's, Cherry St. at Corlear's Hook.	80		Drift.	No rock reached.	Surface 15 ft. above tide. Mather's Report, p. 603.
54	Foot of Jefferson St., E. R.		50	Drift ft. 10 Sand and clay 40		Surface 8 ft. above tide. *Ibid.* p. 604.
55	Dry dock shaft.	330	130			Surface 9 ft. above tide. *Ibid.* p. 603.
56	Cor. Houston and Lewis Sts.		94			Surface 7 ft. above tide. *Ibid.* p. 604.
57	Cor. 7th and Lewis Sts.		93			Surface 5 ft. above tide. *Ibid.*
58	Ave. D and Houston Sts.		96			Surface 10 ft. above tide. *Ibid.*
59	Cor. 5th St. and Ave. D.	109	109			Surface 9 ft. above tide. *Ibid.*
60	Cor. 7th St. and Ave. D.		100			Surface 9 ft. above tide. *Ibid.*
61	Ave, D foot of 10th St.	1194	100		Gneiss.	Surface 8 ft. above tide. Information from D. G. Steele.
62	At F. & M. Schaefer's brewery, 51st St. and 4th Ave.	640			Gneiss.	Bore 8 inches, water abundant.
63	High Bridge, Harlem River.	70		Mud and detached rocks.	Rock not reached in the channel at the depth of 70 ft.	On the S. side of the river at High Bridge, the shore rises 220 ft. at an angle of 30°. N. side. less steep. Depth of water, 16 ft. "A Description of Croton Aqueduct;" pamphlet, 1842. By John B. Jervis.
64	At King's Bridge, Harlem River.					Soundings for some distance on each side of the bridge, reached rock at from 5 to 7.6 ft.

65	At Macomb's Dam Bridge.						For 200 ft. on each side of the bridge the rock is from 18 to 25 ft. below high tide. Farther from the bridge the water deepens rapidly.
66	In the Harlem River, in the line of 8th Ave.	43.8		Water, Soft mud, Sand, Clay,	ft. 18. 12.2 9.7 3.9		Another sounding, about 100 ft. from the one given, yielded a closely similar record. Information furnished by A. P. Boller, C. E.
67	Harlem River, on a line 400 ft. east of Central Bridge.	12–28	12–28				The following soundings to the underlying gneiss (about 100 ft. apart), begin on the S. side of the river and extend about 2000 ft. N. of it. The first nine are in the river; the rest N. of it. [29—27—28—23¾—21—12—17.5—14—8] 6.3—17.2—25—23.5—26.9—38.2—43.1—42.7—42.3—39.3—54.8—60—65.6—53.6—74.9.—71.7—61.7—52.2—51. Information from the Department of Public Parks.
68	Harlem River, at the Madison Ave. Bridge, N. Y. abutment.	55		Water, Mud, Sand, Clay,	ft. 7.5 14.5 10.5 22.5	Rock not reached.	Information from the Department of Public Parks.
69	1st pier from N. Y. side.	75		Water, Mud, Sand. Clay,	ft. 18.2 13.0 7.8 36.0	"	" " "
70	Central Pier.	71.7		Water, Sand, Clay,	ft. 31.4 6.6 33.7	"	" " "

71	Pier at N. end of bridge.	57.5		Water, ft. 4.6 Mud, 14.4 Sand, 11.0 Clay, 7.6 Hard-pan, about 1.0 Clay, 18.9		Information from the Department of Public Parks.
72	At Williamsburg, L. I,	70		Hard gravel.		Mather's Report, p. 604.
73	Fishkill Landing, on the Hudson.	200		Mud with oyster-shells, ft. 80 Clay, 119 Gravel, 1		Bored in 1833, by G. W. Drewery, Information from the same.
	EAST RIVER PIERS. —o—					Information for these pier-borings was furnished by the Department of Docks, N. Y. City. Measurements from mean low water.
	200 ft. eastward of the building line of South St.			These borings passed through a series of very varied alterations of mud, sand, clay, coarse and fine gravel, boulders, etc., occasionally with shells, and sometimes containing vegetable matter and logs. Above all these, rests a layer, usually of 10 to 30 feet thick, of "dock-mud." The lowest layers, next to the "bed-rock," are in most cases stony or gravelly.		
74	Pier No. 1.	25.99	25.99		Granite.	Depth of water, 3.16 ft.
75	Pier No. 2.	22.02	18.77		Granite.	Depth of water, 4.6 ft.
76	Pier No. 6.	24.53	20.94		Syenitic granite.	Depth of water, 1.44 ft.
77	Pier No. 9.	31.52	29.93		Syenitic granite.	Depth of water, 1.27 ft.
78	Pier No. 12.	34.62	30.95		Syenitic granite.	Depth of water, 1.62 ft.
79	Pier No. 15.	54.93	53.23		Granite.	Depth of water, 0.27 ft.
80	Pier No. 18.	163.39	159.89		Granite.	Depth of water, 4.48 ft.
81	Pier No. 21.	138.16	135.91		Granite.	Depth of water, 6.01 ft.
82	Pier No. 24.	194.37	146.62		Granite.	Depth of water, 3.95 ft.
83	Pier No. 28.	100.72	98.06		Granite.	Depth of water. 6.0 ft.
84	Pier bet. Nos. 33, 34.	111.46	108.79		Granite.	Depth of water, 7.21 ft.
85	Pier No. 37.	87.78	85.28		Granite.	Depth of water, 12.45 ft.
86	Pier No. 41.	96.15	90.99		Granite.	Depth of water, 14.49 ft.

HUDSON RIVER PIERS.

	Borings 250 *ft.* from the E. building line of the river street.	Mean low water.	Dock mud.	Lower deposits	Depth to rock.	Mean low water.	Dock mud.	Depth to rock.	Borings at the ends of the Piers.
87	Pier No. 1 (new 2).	26.4	6.2	2.6	35.2	47.5	3.2	50.7	
88	" No. 3 (new 3).	14.9	4.6	20.7	40.2	41.4	3.7	45.1	
89	" No. 6 (new 6).	3.	17.7	21.5	42.2	42.2	3.1	45.3	
90	" No. 10 (new, between 8 and 9).	5.6	23.9	17.4	46.9	35.6	11.3	46.9	Pier No. 8, new.
91	" No. 13 (new, between 10 and 11).	5.	16.5	19.	40.5	35.1	11.7	46.8	Pier No. 11, new.
92	" No. 18 (new, between 11 and 12).	2.6	22.6	19.1	44.3	33.7	9.5	43.2	Pier No. 12, new.
93	" No. 24 (new 15).	1.8	43.	6.2	51.	32.6	16.	48.6	
94	" No. 28 (new 18).	4.1	11.3	60.	75.4	31.7	29.4	61.1	
95	" No. 30 (new 20).	3.6	11.4	70.6	85.6	32.4	31.6	64.	
96	" No. 35 (new 24).	7.9	29.7	43.3	80.9	29.2	21.	50.2	
97	" No. 38 (new 27).	6.9	19.3	53.9	80.1	26.6	20.1	46.7	
98	" No. 39 (new 29).	7.8	18.7	54.9	81.4	23.8	47.3	71.1	
99	" No. 42 (new 33).	3.8	24.	52.3	80.1	15.6	57.4	73.	
100	" No. 45 (new 37).	8.7	34.1	43.4	86.2	23.6	45.	68.6	
101	" No. 49, old.	5.8	30.3	49.8	85.9				
102	" No. 51, old.	1.5	39.	83.5	124.				
103	" foot of Bethune St.	17.1	44.5	96.3	157.9				10 ft. from the end of the pier.
104	" No. 60, old.	14.	79.5	102.5					20 ft. W. of the bulkhead line. *Rock not reached at* 196 *ft.*
105	" foot of 23d St.	4.2			175,1				
106	" foot of 30th St.	15.7			149.4				
107	" foot of 38th St.	.8			84.8				15 ft. E. of the bulkhead line.
108	" foot of 46th St.	2.6			49.8				
109	" foot of 57th St.	10.8			28.9				8 ft. from the end of the pier.

Note by the Editor.

[It is regretted, that owing to the large amount of space required, it has proved impossible to give the detailed sections, carefully prepared by the author of this paper, from official records of the several pier-borings on the East and North Rivers. In the case of the latter, it will be seen from the Table that the "lower deposits" lying between the "dock mud" and the bed-rock, and reaching in some cases a thickness of 100 feet, disappear almost wholly in the short distance westward to the ends of the piers. Where these end-borings are recorded, the mud, with a few slight exceptions, rests directly upon the rock-bottom; while the miscellaneous succession of sand, clay, gravel, boulders, shells, vegetable matter, etc., found under the piers on both rivers, nearer to the shore, is wanting.

In the case of the piers above 23d Street, it was not practicable to judge clearly of the line of demarcation between the modern mud and the older deposits below, so that these columns are left blank.

Attention may be called, also, to the transverse valleys indicated by the increasing depth of the bed-rock on both sides of the city (in passing northward from the Battery), culminating at pier 24 E. R., and the foot of 60th Street, N. R. The pre-glacial rock-surface of Manhattan Island needs fuller and further illustration for its proper determination, and all facts of this kind should be carefully recorded and preserved.]

———o———

MINERALS OF THE TRAP.

The following is a list of the mineral species and varieties discovered up to the present time at Bergen Hill.

ZEOLITES. Thomsonite, Natrolite,* Analcite,* Chabazite,† Gmelinite,† Stilbite,* Sphærostilbite,† Heulandite.†

OTHER SILICATES. Apophyllite,* Prehnite,* Laumontite,* Pectolite,* Datolite;*Orthoclase, Hornblende, Byssolite,† Augite; Prochlorite; Sphene.†

OTHER SPECIES. Calcite,* Siderite;† Quartz,† Hyalite;† Pyrite, Chalcopyrite,† Blende,† Galenite.†

Besides these may be mentioned some species that are but imperfectly determined as yet; among these are the chloritic mineral that has been called Diabantite, and the "Brown pectolite," which appears to be a magnesian alteration of pectolite.

Those species followed by a * are abundant and yield choice specimens: those marked with a † are found but rarely and in small quantities.

MINERALS OF THE SERPENTINE.

The serpentine ridge of Hoboken has long been celebrated as a locality for magnesian minerals. The following species are thence obtained.

Brucite, Nemalite,* Marmolite,* Magnesite (compact porcellanous),* Hydromagnesite,* Aragonite,† Dolomite, Chromite.†

The species Brucite and Dolomite are probably exhausted, as little or none of either has been obtained for years past. The same signs are used as for the trap minerals.

———o———

APPENDIX.

Notes from L. B. Ward's pamphlet on the Soil, Contour and Drainage of Hudson County.

TOPOGRAPHICAL DIVISIONS OF THE COUNTY.

	Square Miles.	
East of Hackensack River:		
Original upland, - - - - - -	21.5	
Made land on Hudson River and N. Y. Bay, -	1.0	
Meadows east of Bergen Hill, - - -	2.5	
" west " " - - -	8.4	
	——	33.4
West of Hackensack River:		
Upland, - - - - - -	4.4	
Meadow, - - - - - -	6.8	
	——	11.2
Total area of land (about), - - -		44.6
Recapitulation:		
Total upland in the county, - - -	25.9	
" meadow " " - - -	17.7	
" made land " " - - -	1.0	
" water surface within the county lines, in Newark Bay, Passaic and Hackensack Rivers, - - - - -	6.4	
" area included in Hudson County (about),	51.0	

Extent of shore line, - - - - - -	48 miles.
Extreme length of County, - - - - -	14½ miles.
Greatest width, - - - - - - -	7 miles.
Least width (about), . - - - - -	½ mile.
Land reclaimed between Paulus Hook and Hoboken, -	900 acres.
" " in New York Bay, east of Communipaw,	200 acres.

DISTRIBUTION OF THE POPULATION IN 1875.

On uplands, east of Bergen Hill,		66,000
" marsh, " "		23,000
" summit and western slope of Bergen Hill,		67,000
" uplands, west of Bergen Hill,		7,000
Population of entire County,		163,000

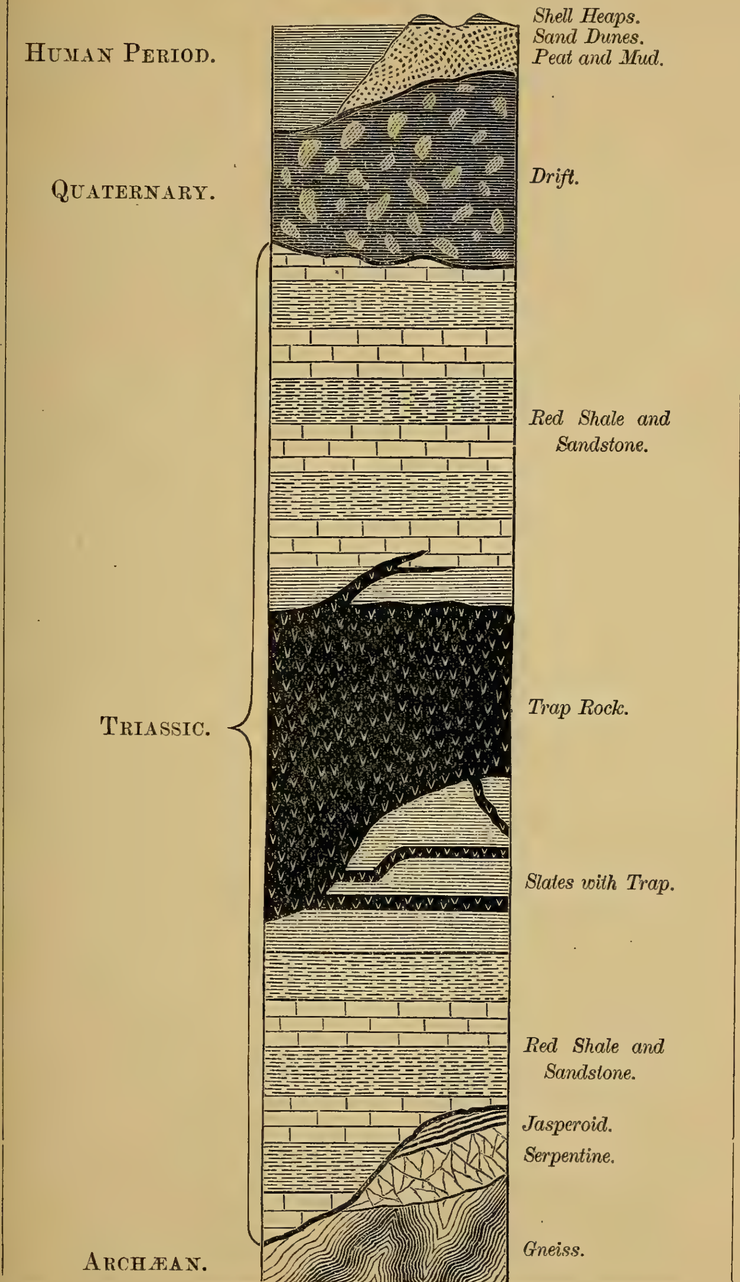
Population living on trap estimated as follows :

On Bergen Neck,	6,000	
In Jersey City,	44,000	
In northern portion of County,	15,000	
		65,000
On Triassic sandstone (west of Bergen Hill),		7,000
On drift, æolean sand, etc., in Jersey City,		55,000
" " " in Hoboken,		11,000
" marsh in Jersey City (35 acres),		9,000
" " Hoboken (140 acres),		14,000

The mean range of the tide in the waters of Hudson County is as follows :—

New York Harbor,	4.4 feet.
Newark Bay,	4.8 feet.
Passaic River, at Newark,	5.0 feet.

GENERALIZED SECTION, HUDSON COUNTY, NEW JERSEY.



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V.—*On Zinc Desilverization.*

BY T. EGLESTON, PH. D.

Read January 7th. 1878. (and revised to June, 1880).

When lead ores contain silver, or when it occurs in other ores in districts where lead ores can be had, they are smelted alone or together and the silver afterwards separated from the lead. The silver is either extracted on the spot or more generally sent to the East to be separated there. This material is called "base bullion," a very improper name, since it is not bullion at all, but only argentiferous or work-lead; and although this term is current in the West, it should not be adopted in technical literature. The furnaces in which the ores are smelted are almost invariably shaft-furnaces, as the ores are very silicious, and the process used is that of direct or indirect precipitation. The furnaces are usually water-jacketed and generally provided with Arendt's tap. The works which treat these ores are situated for the most part in Nevada, Utah and Colorado. A few furnaces have been erected in the East, as at St. Louis, Mansfield Valley near Pittsburgh, and in the vicinity of New York; but, as a general thing, it will not pay to transport the ores which come from all the Western territories, to the East, when there are works competing for them at home, unless they are exceedingly rich, or there is some special business reason why they should be treated here.

It is not proposed to give a description of the process of smelting, which in many respects is peculiar to the West, but only some peculiarities with regard to a few of the works from which the details of desilverization have been taken. These are the Germania Works, Salt Lake, the works of the St. Louis Smelting and Refining Company, at Cheltenham, Mo., and those of the Pennsylvania Lead Co., at Mansfield Valley, near Pittsburgh, Penn.

The Western works treat ores which come principally from

Utah. They are earthy carbonates and sulphates, with some galena, such as are found in Little Cottonwood and Bingham Cañons. From the former place, they contain from 10 to 40 per cent. of lead, from 70 to 150 oz. of silver, 1 to 3 oz. of antimony, and a trace of arsenic and zinc. From Bingham Cañon they contain 30 to 50 per cent. of lead, and 10 to 20 oz. of silver. The copper in these ores is sometimes as high as 6 per cent. They are transported on an average 2,000 miles, some of them being brought from New Mexico. Some argentiferous blende from Colorado contains 450 oz. of silver, 10 per cent. of lead, and 20 per cent. of zinc. When these ores have been dressed, they are made into bricks for treatment in the shaft-furnace. The Utah ores are made the base of the treatment. The works also treat argentiferous lead from all parts of the country. The ore arriving at the works is sampled and assayed. When it is purchased at the mine, it is sampled by the agent of the company, and assayed at the works. When the assay of the agent's sample does not agree with that of the mine-owners, they send a sample.

At the Wyandotte works, the sample is taken very simply. The ore, crushed fine,* is spread evenly over an iron plate, and the sampler, Fig. 1,† which is simply two iron bars bent at right angles and riveted together, is put down on it, separating the ore into four parts ; opposite parts are taken, a new pile made and divided in the same way, and so on until the sample is complete. The argentiferous lead is assayed on a sample taken from the top and bottom of both ends of the pig, and the mean of the two is accepted as the value of the whole. Each lot of ore and lead is kept separate as far as possible. They are not, however, treated separately, as this would involve too much trouble and expense. The separation is only made so as to treat material of about the same value together, or to add it, in the treatment, as different parts of the process require it. The owners are either paid for it at prices for the gold, silver and lead, which are fixed by the works or regulated by the market,‡ or the metals when separated are delivered to the owner, a certain sum being deducted for expenses, loss and profit.

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* Engineering, London, Eng., Vol. 22, p. 495. ‡ Engineering, Vol. 22 p. 200.

† The figures illustrating this paper are numbered consecutively on Plates III to XIII.

The Germania Works are situated at Flack's Station, on the Utah Southern R. R., six miles from Salt Lake City. They treat silver-lead and also ores which they purchase in the open market. They have one shaft-furnace, and their capacity is 40 tons of argentiferous lead and 3 tons of ore a day. The value of the product of the works in copper and lead counted together, silver, and gold, in 1874, was $1,350,000, in about the proportions of 5, 6, 2. The coke used comes from Connellsville, and costs $30.00 per ton.

At Cheltenham, there are two shaft-furnaces, but only one is in blast at a time. The furnace is 10 feet high, 4 feet 6 inches in diameter at the throat, and 3 feet 6 inches at the hearth. The hearth is 2 feet deep from the tuyeres down. The water-jacket is made of wrought iron, riveted together in three parts, and extends four feet above the tuyeres. In the west it is frequently made of cast iron. The fore-hearth is 6 inches wide. The furnace has three tuyeres, $2\frac{1}{2}$ inches in diameter. The cinder-tap is composed of a small graphite crucible with the bottom knocked out. The blast is produced by a Sturtevant's blower. The pressure is from $\frac{1}{2}$ to $\frac{3}{4}$ of a pound of mercury. The blast conduit is arranged to discharge into the air, whenever the work of the furnace has to be stopped for a short time for repairs. The bins for holding the lead and material containing it, are on the level of the bottom of the furnace. Access to the charging-level is by an inclined plane.

The fusion-bed is made up of—

Little Cottonwood Ore, - -	Car-loads.	10 to 25
Argentiferous Zinc Blende, from Colorado, - -		10 per cent.
Mill cinder, - - - - - - -		20 "
Lead slag, containing 3 to 8 per cent. of Lead, - -		70 "

Coke is added, amounting to about 9 per cent. of the charge of ore. When there is a considerable amount of sulphur, 2 to 3 per cent. of old iron is added.

The fusion-bed is spread out over a surface containing 200 square feet, to the depth of 11 inches; so arranged, it consists, commencing on the top, with scrap-iron when there is sulphur, of

$37\frac{1}{2}$	wheelbarrows	of lead slag, - -	7,500 lbs.
50	"	of ore, - -	10,000 "
$37\frac{1}{2}$	"	of lead slag, - -	7,500 "
25	"	of tap cinders, - -	5,000 "

The coke either comes from Connellsville or is Illinois gas-coke. The Connellsville coke weighs 40 lbs. to the bushel. It costs at Cheltenham $10.00 per ton, and the gas-coke costs 7 cents per bushel of 40 lbs. The lead contains about ½ per cent. of arsenic and antimony. When it is very impure, it is polled directly after it is drawn from the tap-hole. Ordinarily it is cast into pigs. The furnace is tapped into a brasqued basin, and the lead cast from there: three to four tappings are made in 24 hours.

The copper is concentrated in an iron matte, which contains a little silver and gold. It forms about 5 per cent. of the total product of the works, and is worked at the end of a campaign, when it is treated with pyrites and concentrated to 50 per cent. of copper. Sometimes a little speisse is formed, when the ore contains considerable arsenic.

The slag varies between a singulo and a bi-silicate. The slag-pot is hung directly under the axle of the buggy, and holds from 650 to 700 lbs. The slag-buggy, Fig. 2, is so arranged that the line of its axis runs through the center of the pot near its top. The pot is caught by three hooks, which prevent it from tipping. It is always white-washed before it is used. When full, it is allowed to remain until the outside chills for about half an inch, and is then caught by the buggy and dumped. To prevent the pot from falling off when dumped, a projection is placed on the front of the pot, which is caught in the hook on the curved part of the axle. Fifteen tons of slag are produced in the treatment of 10 tons of ore. Of this amount, 30 per cent. is poor and is thrown away; the rest is re-treated.

The number of workmen required for a twelve-hour shift is, below, one founder and two helpers, who wheel away the slag, and above, one charger and one helper.

A campaign with water-backs lasts as long as a supply of ore can be had. If the supply was constant, it would probably be about six weeks. With a sandstone lining, it lasts about the same time; but repairs to the furnace are much more expensive. With a brick lining, it lasts only three weeks. In blowing out, slag is used exclusively, to clean the furnace as much as possible.

The amount of ore treated at Cheltenham is from 500 to 600 tons per month. From 5 to 6 tons per day of lead, containing

on an average 250 oz. of silver, are produced. The prices paid for the silver in the ore in June, 1874, were for medium ore, containing 25 per cent. of lead, for 100 oz. ore, $0.834 per oz.; for 200 oz. ore, $1.01; for 500 oz. ore, $1.17. In addition, the freight to the works is paid, if it does not exceed $15.00 per ton. One dollar per ton additional is paid for each unit of lead above 25 per cent. and deducted in the same way.

At the works of the Pennsylvania Lead Company, ores are no longer treated, but silver lead and material containing silver are purchased from all parts of the United States. The shaft-furnace is used both for smelting the crasses and for the concentration of the copper matte which is produced from the residues containing copper. As the construction of this furnace is interesting from several points of view, a drawing of it is given in Fig. 3. It has charging-doors at two different levels, the lower one, A, being used for the matte, and the upper, B, for the ordinary crasses. There are thus two furnaces of different heights in the same structure. The lower opening is bricked up, and its charging-floor is not used while the crasses are being charged. When sufficient matte has accumulated, the lower charging-door, A, is opened. The upper part of the furnace then serves only as a chimney. The lower part of the furnace is built of common brick, laid up in ordinary mortar by a common mason, up to the mantel, which is about eight feet from the ground. Just under the mantel, a pipe with jets at short distances throws water over the surface of the outside of the brick, the excess of which is caught in a trough. This water keeps the furnace cool. The bricks melt off to within three or four inches of the outside and then remain at this thickness. There are four tuyeres, two at the back and one on each side. Three of these are of phosphor bronze, and one of iron, which answers just as well as the bronze.

To put the furnace into blast, the hearth is filled with coal or coke, and lighted, and this is kept up for three days, or until the brasque is red hot. The blast is, during this time, blown in through the Arendt's tap, C. When the furnace is ready, this is filled with a plug of wood in which a hole is bored. The whole crucible of the furnace is then filled with melted lead. The furnace itself is then charged with one-third coke. When the

furnace is lighted all around, and is bright at the tuyeres, they are withdrawn and plugged up. The first charge consists of one scoop of puddle cinder of about twenty pounds, and ten scoops of coke of about eighteen pounds each. The next charges are made with only half the normal charge, until the furnace is two-thirds full; the last one-third is put in at the normal charge. When the furnace is full, the blast is turned on, and the furnace starts at once with a dark top and in a normal condition. A campaign lasts thirteen months. The concentration of the copper matte takes place on the top of the melted lead. They are enriched up to not less than 40 per cent. They contain 25 to 40 ounces of silver, and are sold to Baltimore.

The process of desilverization, as conducted in the works at Cheltenham, Salt Lake, and Mansfield Valley, consists of—

1. Softening the lead.
2. Incorporation of the zinc and separation of the zinc scum.
3. Refining the desilverized lead.
4. Treatment of the zinc scum.

The object of the desilverization, as performed in these works, is to concentrate all the silver into a very small quantity of an alloy of zinc and lead, so rich that the lead resulting from its distillation will contain 8 to 12 per cent. of silver, and to leave behind in the kettles, lead which will contain not over 5 grammes of silver to the 100 kilogrammes, and not more than 0.5 to 0.75 per cent. of zinc, and be pure enough to make white lead, and hence command the highest market price.

1. *Softening the Lead.*—As the argentiferous lead comes from all sections of the country, and contains a number of impurities in variable proportions, it must be refined or softened before it can be desilverized. The furnace used for this purpose is called the softening-furnace, in most of the works. At the Germania Works it is called the A furnace. It is a large reverberatory, with a cast or tank iron basin, into which the hearth is built.

The object of this iron basin is to have a furnace so cool that if the lead goes down into the hearth it will chill, or if the furnace is very hot it will be caught. The larger the furnace the better. Made of cast iron, its size is limited; made of

tank iron, there does not appear to be any reason why it should not be of double the size, except the uncertainty of being able to purchase the supply of lead to work continuously. With an uncertain supply, it is better to multiply furnaces, as a small amount can be better and more economically treated in a small than in a large furnace. There is a point, however, beyond which it will not be profitable to increase the size, and this will be the quantity that can be held by the kettles. The limit in the kettles will evidently be that at which a man can no longer work the kettle conveniently.

The fireplace at Cheltenham is 2 feet 3 inches wide and 5 feet 6 inches long. The grate is 12 inches below the bridge; the bridge is 2 feet 2 inches below the roof, 1 foot 6 inches above the hearth, and 2 feet 10 inches wide. The hearth is made of a cast iron basin which is 15 feet 5 inches long, 9 feet 6 inches wide in the middle, and 5 feet 3 inches at each end, 2 feet 4 inches deep, and $1\frac{3}{4}$ inches thick. It weighs 8 tons, and is calculated to hold 25 tons of lead. At Cheltenham, the pan forming the bottom of the furnace is cast in one piece. At the Germania works, it is cast in three pieces and bolted together. This latter method is the cheapest; but if any of the bolts become loosened, there will be a loss of lead, to avoid which the works at Cheltenham had the pan made in one casting. At the Pennsylvania Lead Works, the pan is made of tank iron about one quarter of an inch thick, which is riveted. It is now proposed to water-jacket all of these furnaces, which will both reduce the quantity of repairs to be made to them, and shorten the time spent upon them. The doors of this furnace are counterpoised with pigs of lead, so that they can be very easily moved. They are beveled and fit into a slot, so that when they are closed and luted they are hermetically sealed.

The hearth proper is built on the iron pan bottom. It is made of fire-brick laid in the form of an inverted arch, placed on a bed of coke next the pan, which is covered with a layer of brasque. The side walls resting on it bear against projections on the rim of the sides of the pan. These precautions are necessary in all iron pan hearths, to prevent the rising of the hearth from the lead penetrating below it, and breaking it up. Notwithstanding all the precautions taken against it, this accident, which causes great inconvenience and loss, happens

so often that, at the Germania Works, holes are now bored in the angles of the bottom and sides of the pan, so that the lead cannot collect. The flowing lead warns the men, before any serious accident has happened, that it is time to make repairs. These furnaces should all be placed at the highest point of the works, so that the lead and other products may descend by gravity from one furnace to the other.

The usual charge at the Germania and Cheltenham works is from 22 to 24 tons, depending on the purity of the lead. In the works of the Pennsylvania Lead Co., at Mansfield Valley, they sometimes charge as much as 25 to 26 tons, the charge depending on the quantity of crasses that the lead makes. It is always made at Cheltenham so as to produce about 20 tons at the end of the operation, or a quantity sufficient to completely fill one kettle. When the furnace is hot, the whole charge melts in about two hours. It remains in the furnace from 6 to 18 or even 24 hours, depending on the work in the kettles, which must be kept full. During this time it is kept at a low heat, and air is allowed to have free access to the surface of the metal.

The operation of softening consists in melting at a very low temperature, the object of which is to separate the copper by liquation, as it is much less fusible than lead. The scums containing the copper are drawn with a tool made of birchwood, so as not to contaminate the lead, as would be the case if an iron tool was used. It is always necessary to endeavor to remove all the copper, whether gold is present or not. The gases in the furnace are oxidizing, and crasses containing the oxides of the foreign metals rise to the surface. At the end of three hours the temperature is raised to a dull red heat. The bath is kept for twelve to fifteen hours if necessary, at the same temperature, and frequently rabbled to bring the impurities to the surface. If the lead contains from 3 to 4 per cent. of impurities, the crasses are only drawn as they form, but if more impure, a steam-jet blast is discharged directly into the bath to produce the oxidation, and the crasses removed several times; but if the lead is moderately pure, the crasses are drawn but once, which will generally be at the end of six to seven hours. The first crasses will amount to from 1.5 per cent. to 2.5 per cent. of the charge, and are taken off at the end of from 5 to 7

hours. Before drawing them, they are mixed with coal on top of the melted charge, to reduce any oxide of lead, and are then drawn; and if they form again they are removed. When they no longer form, the furnace is cooled gradually, but is kept above the melting-point of lead. The crasses are drawn from the working-door and are collected in a bin, where they are allowed to accumulate until there is enough to work.

When litharge commences to form, the crasses are no longer drawn, but are left in the furnace after the lead has been tapped. In refining the next charge, they give up their oxygen to more easily oxidized metals, and thus help to separate them from the lead. Quick-lime is usually added as soon as they commence to form, to keep the litharges from cutting.

Sometimes all the impurities have been removed at the end of 12 hours or less, but the charge in the furnace must stand until the desilverizing kettles are ready. This is done by simply shutting the dampers, and adding only just enough fuel to the fireplace to keep the charge melted; but as all the compounds of arsenic and antimony are very fusible, the softening must be kept up as long as these form With a charge of 26 tons, at the Pennsylvania Lead Works, from 24½ to 25½ tons of softened lead remain in the furnace.

It often happens that the charge is ready for tapping, but the desilverizing pots are in use; so that the lead is kept in the furnace at the melting point until the pots are free. It is cheaper, even if the lead is extremely pure, to keep it melted in the furnace during the time necessary, rather than to cast it and re-melt it.

At Cheltenham, the tap-hole opens into a deep but narrow trough lined with brasque, from which the lead is syphoned off with a Steitz syphon, Fig. 6. The brasque is made of $\frac{4}{5}$ clay and $\frac{1}{5}$ coke-dust. It is made as dry as it can be stamped, and is then carefully shaped and cut down to make the arch leading into the furnace. When the kettles are ready, the furnace is tapped. The tapping-spout is very large, and during the time of casting exposes a large surface to oxidation, thus increasing the losses in lead. If the furnace was sufficiently high above the pot, the lead could be tapped by a gutter directly into the

kettles. The contract is always made to have the kettles cast bottom down.

At the Germania Works, the tapping is very inconveniently done through an iron pipe, 40 feet long and 5 inches in diameter, with holes cut into it at intervals to facilitate the removal of dross which might clog the pipe. It is necessary to heat the whole length of this pipe, to prevent the lead from chilling. This is done with coals suspended in pieces of sheet-iron under it; but there must be a shield between the fire and the pipe to keep the latter from cracking.

As the softening-furnace is always above the kettles, it would seem easy to run the lead into the kettles by gravity, in a trough of some kind. The distance, however, would have to be short, or there would be danger of the lead becoming too cool. At the Pennsylvania Lead Works, there are three of these softening-furnaces, each one having three desilverizing kettles. At the Germania Works, there are two, with five kettles each; at Cheltenham, one, with three kettles.

The crasses from the softening-furnace are first liquated, to remove any excess of lead they may contain. At the Germania Works, this was formerly done in a reverberatory liquation-furnace of peculiar construction. The hearth was 3 feet deep; 18 inches above it a set of grate-bars was placed; the skimmings were placed on these, and the carcasses remained there while the lead flowed through. The first crasses drawn contain most of the copper. They are always kept separate from the others. The carcasses from the liquation-furnace are put through the blast-furnace at the end of a campaign, with pyrites, in order to concentrate the copper in a matte. They produce some hard lead, which is treated with the lead of the other crasses.

At the Germania Works, a copper matte is produced which contains 20 per cent. of copper, 20 to 25 oz. of silver, and a slag containing 10 oz. of silver. The matte is concentrated to 40 per cent. of copper, and is sold.

The assays of three of these concentrated samples contained—

	No. 1.	No. 2.	No. 3.
Silver,	113.54 oz.	88. oz.	94.66 oz.
Gold,	1.18	1.02	1.02

From the dust-chambers connected with this furnace, only a

small amount of material is collected, and this very near the furnace. It contains only from 3 to 4 oz. of silver. The other crasses are treated in a reverberatory furnace. The materials being at first only partially reduced, the first lead which flows carries most of the silver and is put to one side. The charge is then completely reduced. The product is a very hard lead, which is allowed to accumulate until there is enough to make a charge in the softening-furnace.

If the ores contain a very large amount of antimony, there will be two or three sets of crasses after those containing copper have been removed, which will be mostly very impure litharges. The lead produced from them is a compound of arsenic and antimony, which is not refined, but sold as hard metal. The loss in lead in softening is about $2\frac{1}{2}$ per cent.

2. *Incorporation of the Zinc, and Separation of the Zinc Scums.*—To effect the desilverization, there are at Cheltenham three kettles, set in a triangle, at Mansfield Valley a series of three kettles set in a row, and at the Germania Works, a series of five, set as shown in Fig. 4, the first two holding 20 tons each; the next two, 7 tons, and the last, 4 tons. These kettles are set in masonry, with a fire-place underneath them. The furnace is tapped into the two upper ones alternately. The upper kettles at Mansfield hold 23 tons. The upper kettles at Cheltenham weigh 4,700 lbs. each, and cost between $400 and $500 each. They are 6 feet 6 inches in diameter, and 3 feet deep.

At the Germania Works, the discharge-spout is cast on the bottom of the kettles, and is constantly breaking. At Mansfield, the middle one has a spout at the bottom, which communicates with the third and smallest. These kettles are filled with melted lead from the softening-furnaces. When they are full, they are heated up to the melting-point of zinc, which takes about one hour. It is important that the heat should be high enough to melt the zinc readily. The kettle is so large that there is but little danger of over-heating. When the temperature is at the right point, the zinc is added. At the Germania Works and at Mansfield, the zinc is thrown in or laid on the top of the lead, and incorporated as it melts. At Cheltenham, it is placed in an iron cage, which is let down to the bottom of the pot. The amount of zinc to be added will generally be about one pound

for every $5\frac{1}{2}$ oz. of silver. This will usually amount to between 250 and 550 lbs. to each kettle. In general, with ores varying from 100 to 300 oz. of silver, 1.4 to 3 per cent. of zinc is added. It is not all added at once, but sometimes in two and sometimes in three additions, the proportions being determined by assay in each case. These additions should be so regulated as to make the richest possible alloy at first, in order to shorten the process as much as practicable, and to diminish the liability to oxidation when it is liquated.

At Mansfield, the lead contains from 50 to 400 ounces of silver. To this, from one and one-tenth to two per cent. of zinc is added, in four additions. The zinc is thrown in on the top of the melted lead, and then is stirred into it by a tool, five by ten inches, with a long handle. After the first addition, it is stirred for half an hour. The scum is then allowed to rise and cool, until there is a ring of $3\frac{1}{4}$ inches around the outside. It is then skimmed with a perforated skimmer until the lead is bright. The other additions are made in the same way.

At the Germania works, for a charge containing 60 oz. of silver and $\frac{1}{3}$ oz. of gold, 1.85 per cent. of zinc was added. For a charge containing 140 oz. of silver, and 3.8 oz. of gold, 2.3 per cent. of zinc was used. Of this, 0.5 was added in the first addition, 0.4 in the second, and 0.1 in the third. For a charge containing 350 oz., 2.6 per cent. of zinc was used.

The following Table, prepared by Mr. A. V. Weisse, of the Germania Works, gives the amount of zinc used in two charges.

Example.	Total weight of softened lead.	Silver contained in grammes to the 1000 kilos.	Gold contained in grammes to the 1000 kilos.	Zinc used.
No. 1.	402.442 lbs.	4300.	125.	2.3 per ct.
No. 2.	402.224	4256.7	127 45	2.6 per ct.

To be sure of lead at 5 grammes from lead containing 1,000 to 1,400 ounces of silver, at least $1\frac{1}{2}$ per cent. of zinc must be

added. Pure zinc is no longer used for all these additions. The second, third and fourth scums of a previous operation, which are not very rich in silver, are used for the first and sometimes for the second addition, thus greatly reducing the amount of zinc required for the operation. When the lead is very poor in silver, the first addition is used several times, in order to make it as rich as possible. The object of dividing the additions is to arrive, as quickly as may be, at the highest percentage of silver, and to get an alloy so rich that there will be little liability to oxidation in the subsequent liquation, thus shortening and cheapening the process. The amount to be added in the first charge will depend on the amount of copper in the lead. If it contains but a small amount of copper and some gold, 100 lbs. are added, at Cheltenham. If there is much copper, more zinc must be added to bring out the copper, as most of the copper comes off with the first crasses. If gold is present in large proportion, the quantity of zinc must be increased, since all the gold comes off with the first scums. If no gold is present, two-thirds of the charge of zinc necessary for the whole operation may be added in the first charge. It is then stirred from one-half to three-quarters of an hour with a flat spatula, which is 17 inches in diameter, attached to a piece of gas-tubing 6 feet long. The temperature during this time is kept above the melting-point of zinc. The tool is made to work from the sides toward the center, with a downward motion at the same time. When the zinc is thoroughly incorporated, the fire is drawn, and the kettle allowed to cool until the zinc alloy, which contains the silver, rises and floats on the top of the melted lead. This time depends on the heat of the metal, and on the season of the year. In summer, it is four hours; in winter, only two. The skimmings are taken off in perforated ladles, and put into one of the smaller kettles. These first skimmings are carefully separated from the rest, if the lead contains either much gold or much copper, or both.

At Cheltenham, the skimmings from the first addition of zinc are charged into a small kettle between the two large ones. At the Germania works, kettles Nos. 1 and 2 are skimmed into Nos. 3 and 4. If the skimmings come from the first addition of zinc, they are partially liquated in Nos. 3 and 4, and trans-

ferred to No. 5, where the liquation is completed. All the lead in Nos. 3 and 4 is then put back into Nos. 1 and 2, ready to receive the second addition of zinc. The skimmings from the 2d, 3d, and 4th additions of zinc are not liquated, but are used over again. The amount of labor required is one man to each kettle. The kettle is left until it is full, and is then fired up and partially liquated, which takes about an hour. The kettle must not be heated too hot in this liquation, for there would be danger of oxidizing the zinc, in which case the silver would go back to the lead. The lead separated in liquation is put back into the large kettle, No. 1, before the second addition of zinc.

At Mansfield, all the skimmings except the first, which contains copper and may contain gold, are ladled into the middle kettle, which is kept heated, and are liquated at once, the lead flowing into No. 3. The lead which collects there is put back into No. 1 with the next charge of lead. At Cheltenham, the zinc skimmings are taken from kettle No. 1, and liquated in No. 2. While the second addition of zinc is being made, the liquated lead is removed to No. 3. The six tons in No. 3 are put back into No. 1, after the second addition of zinc.

The lead remaining in the kettle after the first skimming should not contain more than 20 oz. The zinc for the second and third skimmings is not liquated, but used in the next operations. The skimming is made into the adjacent kettle. After making an assay of the melted lead, to ascertain what is required, the next addition of zinc is made, and the skimming continued about the same time. After the second skimming, there should not be more than 10 to 15 oz. of silver remaining. An addition is made, if the assay shows it to be necessary. The last two charges are placed partly on top of the melted lead and partly in the cage. It is then stirred for three-quarters of an hour and left to cool down. The skimmings are liquated as before. The lead contains from one to one and a half ounces of silver. A new addition of zinc of about 100 lbs. is made.

At Cheltenham, there is not more than one-sixth of an ounce of silver remaining when the lead is tapped into the refining furnace. Frequently, the last skimmngs are too poor in silver to admit of treating. They are put to one side, and form

either a part or the whole of the first additions of zinc in the next kettle.

At Mansfield, poor lead is not tapped if it contains more than one-tenth of an ounce of silver to the ton, and the merchant pig assays 0.075 to 0.15 oz.

When the Germania works were first built, the Flack process was used. The liquated zinc skimmings were charged in a blast furnace with a very basic slag, and small pressure of blast. The result was rich lead, and a rich slag. In the condensation chambers, a very impure oxide of zinc was collected, which was but a small part of that actually charged in the furnace. As the use of this process occasioned a loss of from $18,000 to $25,000 a year in zinc, it was abandoned, and the Faber du Faur furnace was introduced in its place.

It is always best to use good zinc for the separation. An attempt was made at the Chicago Silver Smelting and Refining Works, to economize in this direction by using scrap zinc; but it was found that the lead, after its use, sometimes contained as high as 18 oz. to the ton, and the attempt had to be abandoned.

The following statement of several charges at the Germania works is made by the Superintendent, Mr. A. V. Weisse: [1]

	No. 1.	No. 2.
No. of lbs. charged in the softening-furnace, - -	41,614	40,120
No. of grammes* of silver, - - - -	5,700	1,980
" " gold, - - - - -	110	10
First addition of zinc, from 2d and 3d additions of a previous operation, in lbs., - - -	4,000	3,000
* Grammes of silver in lead after first addition, -	1,360	1,160
Second addition of zinc in lbs., - - -	600	600
* Grammes of silver in lead after the second addition,	20	30
Third addition of zinc in lbs., - - - -	80	125
* Grammes of silver in lead after the third addition,	trace.	6

The following tables were prepared by Mr, E. F. Eurich, of the Pennsylvania Lead Co.:

1 Mining Commissioners' Report for 1875.

* The grammes are given per thousand kilogrammes.

DESILVERIZATION.	No. 1.*	No. 2.
Quantity of work lead charged in the kettle -	87,294 lbs.	
Taken off ; "Schlicker" (cuprous oxide) - -	3,497 "	
Pure work lead, - - - - - -	83,797 lbs,	62,895 lbs.
Silver contained, - - - - -	6,305.6 oz.	6,165.9 oz.
Quantity of zinc added, - - - -	1,760 lbs.	1,260 lbs.
Weight of skimmings after liquation, - -	9,525 "	6,362 "
"Abstrick" from dezincation of poor lead, -	7,810 "	3 500 "
Oxides and metallic lead from the market kettle, -	1,000 "	700 "
Lead from liquation of zinc-crust, - - -	808 "	
Market lead, - - - - - -	67,104 "	53,420 "

At Cheltenham, the liquated skimmings, still soft, are thrown on iron gratings from 1 to 1½ inches apart, and pushed through in order to reduce it to pieces of small size, which can be more conveniently introduced into the retort. In most of the works, it is thrown upon an iron plate in front of the kettle, and in order to break it up, is rapidly moved about with a rake, and if necessary cut up with a shovel, so that the pieces are about the size of a hickory nut.

3. *Refining the Desilverized Lead.*—The lead in kettle No. 1, which contains ¾ per cent. of zinc, no matter what the heat is, or how much zinc is added, must be refined, to separate the zinc and get it ready for the market. This operation is one of refining ; but in the West it is known under the name of "calcination." This is done in a furnace with a cast or tank iron bottom, like the softening-furnace, holding about 20 tons. At Mansfield Valley, the bottom is made of tank-iron. Fig. 5 represents the furnace used at the Germania works. The one used at Cheltenham is essentially the same ; it is a little larger, but the dimensions vary only a few inches. The fire-place is 2 feet 3 inches wide and 4 feet 5 inches long. The bridge is eight inches below the roof on the fire-place, and eleven inches on the hearth side. It is 2 feet 10 inches wide, 3 feet 6 inches long, and 2 feet above the hearth. The hearth is 13 feet 4 inches long, and 7 feet 3 inches wide in the middle, and 3 feet 6 inches wide, both at the fire-bridge and the flue. It is

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* No. 1 is lead taken directly from the shaft furnace, which has not been softened. No. 2 is softened lead.

here made of one casting; at the Germania Works it is cast in three pieces, as shown in the section A–B, Fig. 5. The arch is 2 feet 9 inches above the floor of the laboratory. It has three openings, 4 inches square, in the fire-bridge, and two on its side, for the introduction of air. The charge remains in this furnace from 18 to 24 hours. The surface is constantly exposed to the air entering the furnace by the air-holes at the bridge. At the end of the first half of the time that the charge is to remain in the furnace, the bath is skimmed. The skimmings amount to from one to one and a half tons. They contain from 45 to 50 per cent. of lead, and most of the zinc and other remaining impurities. The charge is rabbled, after the oxides have been removed, but any others which form are allowed to remain until the furnace is tapped into the polling-kettle, which is usually about twenty hours after the charge is made, and are then polled. At Mansfield Valley, the refining is done in twelve hours. The lead is not polled, but is cast into pigs directly from the furnace. At Cheltenham, the polling-kettle is placed at the flue end of the furnace. The lead flows into a deep cast-iron channel lined with brasque, from which it is syphoned off. The top of the kettle is about six feet from the floor. Directly in front of the kettle, and about two feet below the floor-level, there is a sunken track upon which a car is run, the top of which comes up to the level of the floor. The car is about six feet wide, and receives the pigs and carries them to the store-house. There is a space of four feet between the car and the furnace.

The polling is done in eight hours. The wood is held at the bottom of the kettle by a crutch, Fig. 7. The same apparatus is used at the Germania works, except that instead of the crutch, the bars are straight and pointed, and holes are bored in the wood to receive them. Short sticks of green wood are used, but to insure a plentiful escape of steam, all the wood for this purpose is kept soaking in a pool of water. Three or exceptionally four pollings are made, the number depending on the quality of the lead; each polling lasts about an hour, so that the furnace is ready to receive a new charge as soon as the one refined in the softening-furnace is desilverized. The

weight of the dross collected from a kettle at the Germania works, which was polled four times, is given below.

1st Polling,	1,301	lbs.
2d "	881	"
3d "	671	"
4th "	290	"
Total,	3,143	"

The crasses from all the pollings, usually amounting to from 1000 to 2100 lbs., are melted, at the Germania works, in a reverberatory furnace, and make common soft lead. The crasses from the softening-furnace, however, make silver lead, which is treated by zinc. Those from refining, which at the Germania works is called calcination, make soft lead of ordinary quality.

The following table gives the quantity of skimmings for examples Nos. 1 and 2, page 95.

From refining-furnace,	31,700 lbs.
Polling-kettle,	20,352 "

Quantity of work lead taken from the polling-kettle, 76.25 per ct.
Silver contained in the market lead, per 1000 kilogrammes, 6 grammes.

The polling-kettles at Cheltenham, are emptied by the Steitz syphon, Fig. 6. To do this, it is first heated and turned over, so that the funnel-end, *a*, is uppermost. The stop-cock, *b*, is then turned, and melted lead poured into the funnel. It is then turned over into the furnace. The joints of this syphon are made of gas-pipe fittings. At first it was supposed to be necessary to make them perfectly air-tight, but afterward it was found that when six or eight threads of the screw were run into the the fitting, the joint was lead-tight, and perfectly flexible. The end of the syphon, where it turns down to discharge the lead, is a simple gas-pipe fitting, to which a handle, *c*, is attached for convenience of moving. While the lead is not being cast, the vertical arm is simply turned up. When the car with the pig-moulds is ready, the syphon is turned down, being held by the handle, and is moved from one pig-mould to the other in succession, as they are filled with lead. The joint is long enough to allow of filling all the moulds without moving the car.

4. *Treatment of Zinc Scums.*—The zinc for the liquation, after eing reduced to small pieces, is distilled. This is done in

graphite retorts in fixed furnaces, as was formerly the case at Bloomfield and Cheltenham, or in Faber du Faur's tilting furnace.

At the Germania works, the Flack process was formerly used, but this was abandoned, and they now charge all the zinc scums in a shaft-furnace with the drosses from refining and ores of all kinds. The result of this treatment is a rich silver lead, but the greater part of the zinc is lost. From a metallurgical standpoint, this treatment is very objectionable, and should not be imitated ; but the commercial conditions in Utah are so peculiar that it has proved financially successful, owing probably to the great skill with which the process is managed; for a bad process well conducted may sometimes be made successful. In almost every other establishment in the country, the zinc scums are retorted. The retorts used at Bloomfield, N. J., Philadelphia, Cheltenham, and the Germania works, are shown in Figs. 8, 9, and 11. They vary but little in different works, and generally are ¾ inch thick on the sides and nearly twice that on the bottom ; the neck is 7 inches long and the body of the retort is 2 feet. The diameter at the extremity of the neck is 5½ inches, but where it joins the body it is 8 inches. The body in its widest part is 14 inches, but it is only 9 inches at the end. These retorts are made of New Jersey clay and chamotte with 25 per cent. of graphite. They were formerly one of the largest items of cost in the conduct of the operation.

One of the first furnaces used for the distillation of the zinc, was invented by Mr. W. M. Brodie, and has been constructed in several works. It consists of a large chamber, in which six retorts are placed in two levels, as shown in Fig. 8. These are heated by a fire-place, 2 feet 10 inches long and 16 inches wide, with cast-iron grate-bars, which is blown by a forced blast which enters the ash-pit at *c*, having first been heated in the two hot-air pipes which are placed in compartments above and behind the furnace. The retorts are protected from the direct action of the fire by the arches, *d*. The heat escapes by the flues above the retort-chamber, passes into the chamber above, down at the back, and out of the furnace by an underground flue. The retorts are the ordinary graphite retorts, holding from 450 to 500 lbs., so that the furnace would hold from 2,600 to 3,000 lbs. of

alloy at a time. Each retort has a condenser, *h*, attached to it, and in front of it a charging-table, *f*, covered with cast-iron.

It is necessary to remove the condenser, as in the other furnaces, to clean the retort. The furnace is tapped on the back side, at *e*, from holes $\frac{1}{4}$ of an inch in diameter, bored through the bottom of the retort, into moulds placed on the iron ledge, *g*.

If the material charged is clean, the time required for an operation is 12 hours. If it is not, it may require as much as 24 hours, depending on the quality of the material charged. One man does the work of the six retorts. The amount of fuel required is one ton of coal for one ton of alloy. The results do not differ materially from the other furnaces, except that the operation is longer. They were constructed in the now abandoned works at Bloomfield, N. J., and in the works of Messrs. Tatham, in Philadelphia.

The following tables of the results of the working of this furnace have been prepared for me by Mr. C. Kirchoff, Jr., who had charge of these furnaces while they were working :—

Table of charges in the Brodie furnace.

	No. of shifts of 12 hrs.	Lbs. of zinc scum liquated in kettle.	Lbs. of bit. coal used for distillation.	No. of [3]barrows of charcoal	Yield in rich lead.	No. of charges.
No. 1 [5]	19	9,916	22.000	6	8,681	65
" 2 [5]	17	13,656	26,000	6	10,862	66
" 3 [5]	21	19,944	14,000[4] with 1 ton of coke.	3	14,511	60
" 4	26	19,622 [1]	34,000[4]		19,015	73
" 5	26	27,324 [1]	20,000		23,738	73
" 6	28	21,114 [1]			11,927	
with hot air	28	17,300 [1]			14,902	83[2]

1. Mixed with copper scum. 1st scum at first kept separate, but not afterwards.
2. Four retorts were still good.
3. A barrow contains about four bushels.
4. ½ anthracite and ½ bituminous.
5. Nos. 1, 2, and 3 yielded 4,049 lbs. of zinc regained.

The following table covers five runs; unfortunately the lists do not specify how many retorts were fit for further service at the end of a run:

No. of Retorts.	I	II	III	IV	V	VI
1st Run, -	13	7	11	12	9	13
2d " - .	12	10	9	10	9	12
3d " - -	10	13	8	10	12	7
4th " - ,	12	15	12	12	15	7
5th " - -	13	14	7	13	13	13

The figures give the number of charges made in each retort.

At Cheltenham the retorts are set in the furnace, Fig. 9, with the level of the bottom below the mouth, and so inclined that the syphon, Fig. 10, can draw out nearly the whole of the silver lead. Some of it will remain, but this is no disadvantage, as it is not lost. It is collected when the retort is broken. Its presence, however, requires that a reducing temperature should always be kept up in the retort, otherwise litharge would form and the retort be quickly pierced. The furnace is a cube of fire-brick, 3 feet in size, braced in every direction with wrought iron bands 3 inches wide. On the top there is a round hole, *h*, 10 inches in diameter, for the introduction of the fuel; on the front, is an opening for the neck of the retort, *c*, and on the back, a square flue, *g*, leading to the chimney. The retort is introduced from the bottom, The furnace has 12 grate-bars one inch square, and is supported in front on masonry, *b*, built with two steps, each of which is 18 inches high, but vertical behind. The retort is supported on a pillar of brick-work, *d*, resting on the ground, through which the grate-bars pass. It is thus in the centre of the furnace and is surrounded on all sides by fuel. It costs from $14 to $16 and lasts for 15 to 30 turns. When it breaks, it is not because it is worn out, but because the workmen break it in trying to force off the cinders attached to it. Five of these furnaces were arranged in a house by themselves, about a hexagonal chimney, and connected with it by the flue, *g*, 3 feet long. The sixth side of the chimney is occupied by a melting-furnace. Only three of the furnaces are run at a time, the

others being kept in reserve in case of accident or necessary repairs.

The fuel used was at first coke, which was given up because the clinkers attached themselves to the retorts. In trying to remove them, the men constantly broke the retorts by poking them, while the cinder was soft, with iron tools, through the opening for the introduction of fuel. Petroleum was then used with great success, but the furnaces were finally abandoned for Faber du Faur's furnace.

The charge of 380 lbs. of zinc skimmings is introduced with a spoon, immediately after the preceding operation is finished. Two small scoopfuls of small charcoal are added at the same time. The heat is so high that most of the charge melts at once. An allonge, *e*, Fig. 9, 2 feet long, 4 inches in diameter at the small, and 9 inches at the large end, is then put on and luted. It is partially filled with charcoal. The allonge is covered on the outside with sheet-iron, to protect it against accident. It is supported on a cast-iron shelf, *f*, which can be raised or lowered at will by detaching a bar underneath it. This is necessary to prevent the weight of the allonge breaking the retort while the furnace is working. When the charge is drawn, it must be let down so as not to interfere with the syphon, Fig. 10.

The zinc commences to distil in about three-quarters of an hour. Metallic zinc collects in the condenser. Some blue powder and oxide of zinc also form there. The object of the charcoal is to prevent the formation of oxide as much as possible. The zinc is allowed to accumulate, and is drawn from time to time with a spoon into a mould placed in front of the allonge. When the zinc is nearly distilled, a small piece of wood is put into the retort to make a reducing atmosphere, to prevent the formation of litharge, which would pierce the sides, and to form a current of gas from the inside to the outside of the retort. The charge of rich silver lead, remaining after the zinc is distilled, is drawn with the iron syphon, Fig. 10—which must be heated before it is introduced—and the lead is cast into pigs ready for cupellation.

Before the invention of the Steitz syphon, the neck of the retort, which was necessarily built into the masonry of the furnace,

had to be disengaged while it was at a white heat, before the rich silver lead could be discharged from the furnace. The percentage of breakage was thus greatly increased, so that between the necessity of getting rid of the clinkers on the outside of the retort, and the necessity of disengaging the neck every time it was discharged, the number of retorts broken was very large. The syphon proved to be a complete remedy, but was difficult to use, much more so than the polling-pot syphons. The objection to using these furnaces was not only the breakage of the retorts but the large quantity of fuel they consumed. The Brodie furnace, with two tiers of retorts, consumed less than the Cheltenham furnace, but the retorts were more difficult to manage. The use of petroleum seemed to be a real progress, and the use of gas was proposed, when the invention of the tilting-furnace overcame all difficulties, and it is now almost universally used for this purpose.

The general shape of Faber du Faur's furnace is essentially the same as that at Cheltenham; but it is suspended on pivots, so that it is capable of rotation by means of a worm attached ot a hand-wheel, as in the American type of the furnace, Fig. 11, or by means of a lever, as in the German type, used in Newark and in Prussia, Fig 12. The furnace is 3 feet 3 inches by 2 feet 11 inches in section, by 3 feet high on the outside, 2 feet 1 inch by 2 feet 3 inches, and 2 feet 9 inches from the grate-bars to the centre of the arch on the inside. There is an opening 11 inches in diameter on the top, for the introduction of the fuel, and on the back a flue 6 feet 6 inches leading to the chimney. There are 12 grate-bars 1 inch square and 2 feet 9 inches long set on edge. The retort is built into the furnace in the same way as at Cheltenham.

Fig. 13 gives the proposed plan of the furnaces at Salt Lake, showing the disposition of the eight furnaces, *a*, with regard to the main chimney, *g*, and a section across the flue, *f*. At Mansfield Valley, the chimney is at the end of the line of furnaces. The weight of the iron for a furnace is nearly as follows :—

Cast iron box, - - - - - - -	1,260 lbs.
Grate-bar bearers, - - - - - - -	306
Two standards, - - - - - - -	530
Cast iron,	2,096
Wrought iron bars,	181

The iron-work costs from $150 to $165.

The furnace is fired until the retort gradually arrives at a dull red heat, when a charge of 250 to 400 lbs. of the alloy, broken up while still soft, in order to get it of a suitable size for the charge, and mixed with five to six lbs. of small charcoal, is introduced with a scoop. It is brought to the retorts at Mansfield in a box on wheels, about three by three feet, and a little lower than the mouth of the retort. As soon as the retort is charged, the temperature is gradually raised to a white heat, and when the zinc vapors begin to appear, the condenser, made in the same way as that at Cheltenham, is put on. At Mansfield, they use for a condenser a retort, No. 100, with the bottom broken out, and a hole punched in the side to discharge the zinc. A piece of common stove-pipe is attached to the mouth to carry off the flames.

The retorts usually last fourteen to fifteen charges, but some have been made which lasted forty-five. As soon as the zinc commences to collect, a wagon, containing the moulds for the zinc and the support for the condensers, is rolled up against the front of the furnace, which has been entirely free since the charge was introduced. The zinc distils, and is collected in the condenser, and held there by the oxides and blue powder which collect in front, and are used by the workmen to form a dam to hold the zinc back. When sufficient has collected it is drawn into the moulds. The total amount collected as metal varies from 45 to 55 per cent., and is used over again. The blue powder and oxides amount to from 20 to 30 per cent.; these are sold to the zinc works. Some of the zinc is lost by volatilization, and from 0.7 to 1 per cent. retained in the lead.

As soon as the amount of zinc escaping appears in small quantity, the lead contains but little zinc; but as it is desirable to remove, as far as possible, the last traces of it, the heat is kept up, the condenser is removed, and small pieces of wood are put

into the retort to assist the discharge of the fumes. When no more escape, the furnace is tipped down and the contents of the retort discharged into a lined receiver, and there left until cool enough to be cast into pigs. They generally contain from 2,000 to 3,000 oz. of silver, and not more than from 0.5 to 0.8 per cent of zinc. The retort is now carefully scraped with an iron scraper, to remove any slag or other material adhering to the sides. The amount removed in this way is not large; but it is necessary to keep the retort clean, for if the material was allowed to accumulate, it might be difficult to remove it, and there would be a risk of breaking the retorts in doing so. The material so collected, amounting usually to a few pounds, is reduced with the cupellation litharges. The unburned charcoal is put back into the retort. When the retort is cleaned, it is turned up partially, and fine charcoal dust, or a piece of wood, thrown in, to make a reducing atmosphere, and prevent the formation of litharge from the oxidation of the very small quantity of lead attached to the sides of the retort. This precaution is very necessary, for if the litharge was allowed to form, it would soon destroy the retort. The furnace is now turned up and is ready for a fresh charge.

The workmen are obliged to be careful in all these furnaces, that in introducing the coke they do not push too hard on the retort, which is quite soft. The fire must be kept at a constant temperature of white heat throughout the operation, which lasts from 8 to 10 hours according to the percentage of zinc in the alloy. But when the lead contains antimony, it lasts a much longer time.

The only precaution required during the operation, is to keep the temperature high enough to prevent the formation of a crust on the surface of the charge. To prevent this, and to know what is going on in the interior of the retort, without removing the condenser, it is probed from time to time to break the crust, for if it should form, an explosion would be likely to take place. The men can always tell the condition of the heat by looking into the coke-charging hole.

It is very necessary that the current of gas should always be out of the retort. The retort should last from 1 to 20 operations on an average, and it is generally broken before it is worn out; but when much antimony is present in the lead, they last a much

shorter time, so that it is always desirable to soften the metal before treating it with zinc. At Chicago, owing to careless management in not carefully cleaning the inside and outside of the retorts, they lasted for only 9 to 10 operations.

When a new retort is necessary, the furnace must be allowed to cool down, the grate-bars are taken out, and the retort introduced from the bottom.

The flues leading to the chimney, at Mansfield, are made with flaring sides at the bottom, for 18 inches in hight. The sides of the upper part are vertical and are rounded at the top. Every seven feet, at the bottom, a partition is put in, one-third of the whole hight of the flue. In the brick flues, which are five feet high, the partitions are put in every eighteen inches, and further apart. In both the iron and brick flues the most dust is caught near the furnace. The dust settles by gravity in these catches, and as there can be no velocity there, owing to the partitions, it remains there. Short flues of this construction have been found to be much more effective than large condensing chambers.

The amount of zinc in the skimmings is very variable. If it contained 35 per cent. of zinc, 20 per cent. will be recovered as metallic zinc, and 10 per cent. as oxide, which is afterwards reduced, and 5 per cent. will be lost. This last is either in the lead or volatilized in the different operations. If the skimmings contained only 10 per cent., 3 per cent. will be recovered as metallic zinc, 5 per cent. will be recovered as oxide, and 2 per cent. will be lost. No lead or silver is found in the distilled zinc.

This furnace is a very great improvement on all those in which the retort is fixed, as it necessitates the least amount of work being done on it, and at the same time allows perfect manipulation of the furnace.

The following table, prepared by Mr. E. F. Eurich, gives the account of two charges in Faber du Faur's furnace, at Mansfield:—*

* Mining Commissioners' Report for 1875.

DISTILLATION OF THE ZINC RICH IN SILVER.

	No. 1.	No. 2.
Weight of alloy per charge with $\frac{3}{4}$ lbs. of fine charcoal,	353 lbs.	353 lbs.
No. of charges,	27	20
No. of distillations in 24 hours in each retort.	2	2
Total amount of liquated zinc-crusts charged,	9,525 lbs.	6,362 lbs.
Charcoal,	108 "	80 "
Result: Rich lead,	7,609 "	5,221 "
Metallic scraps,	390 "	not weighed.
Charcoal with little metal,	not weighed.	"
Metallic zinc,	770 lbs.	"
Blue powder and oxide,	not weighed.	"
Coke used, in bushels of 40 lbs.,	410.4	276
Quantity of coke per lbs. of zinc-crust,	1.7	1.73

M. Faber du Faur has proposed another furnace, shown in Fig. 14, constructed on the tilting principle, and destined to receive a charge of one ton at a time. The retort, *i*, is made of fire-clay, lined on the inside with graphite. It is 6 feet 6 inches long on the outside, 5 feet 10 inches long on the inside, and 7 inches high. It is placed on a cast-iron frame, *e*, protected by fire-brick, and connects with a condenser, *a*, 12 inches in diameter and 2 feet 3 inches high on the inside, which is placed on wheels so as to be moved when the retort is to be tilted. The retort is moved mechanically from the fire-place end at *f*. The furnace may be constructed for solid fuel, as in the drawing, but it was invented exclusively for the use of gas and hot air. The object in the construction of the retort was, to have the largest possible surface for distillation, with the shallowest depth of metal, which will not exceed $2\frac{1}{2}$ to 3 inches. It was proposed to make the retort in two parts if necessary. This furnace has never yet been built, on account of the commercial depression. Contracts for its construction were once prepared, but not completed. It seems to have the advantage of being able to treat a large quantity expeditiously, and thus economize in labor and material.

The silver lead is cupelled in an English cupelle furnace.

At the Germania works, there are two of these furnaces; at Cheltenham only one. They are blown with a steam jet in both places. They are usually at work one week, during which time they treat 35 bars of 65 lbs. each per day. The silver is then tapped, and the test changed, or the other furnace used. The

silver bullion produced weighs about 9000 oz. and is usually 990 to 995 fine, and contains both silver and gold, the proportions of both metals varying with the bullion or ore purchased. The litharges produced are reduced in a reverberatory furnace.

At Mansfield Valley, the cupelle is made of the best hydraulic Portland cement, moistened enough to ball in the hand, and stamped in an iron mould. The test is three by four feet on the inside. The iron frame which supports it is flanged on the bottom at right angles to the rim, which is $7\frac{1}{2}$ inches high, while the flange is $5\frac{1}{2}$ wide. The test is made either on an iron mould, which gives the shape to the inside, or is cut out of the material after the frame has been stamped full. At first they were always cut out, now they are generally stamped over the mould. When made, the cupelles are left to temper for four weeks, to insure a good test. They could be used after a week, but it is better not to do so. The test is supported in the furnace on an iron plate, and is held up to its place by four large screws. The charge of a rich alloy is 1400 lbs. The cupelle is used a week, and cupelles from ten to twelve tons up to 996 fine, and that directly from the lead. The lead is added in the cupelle till just before it is too rich, then cleaned off and the silver is refined, and is run into the brick moulds directly from the cupelle. A little copper is added, to prevent the spitting of the silver. The copper absorbs the oxygen, and prevents the spitting. When any copper is present in the lead, even when gold is present, it rarely ever spits. When the silver is ready to cast into bricks, the test is loosened, and a curved bar is placed on a support made for the purpose underneath it. The whole test is then ra sed, and the silver, tipped at once into the moulds for the bricks, is 994 to 996 fine. This cupelle thus allows of casting, without refining in a separate furnace. It is the invention of Mr. Eurich, the manager of the Pennsylvania Lead Works, and is one of the many ingenious additions to metallurgical progress which he has made.

The following tables, prepared by Mr. E. F. Eurich, give the results of cupellation at Mansfield :—*

* Mining Commissioners' Report for 1875.

SILVER OBTAINED.	No. 1.		No. 2.	
	ozs.	ozs.	ozs.	ozs.
Quantity of silver in the refined work lead		6,305.6		6,165.9
Silver tapped from the cupelle .980 fine 6,088.75 oz. - - -	6,031.66			
Silver tapped from the cupelle .989 fine 5,714.50 oz. - - -			5,645.9	
Small pieces of silver from the cupelle .970 fine 150.00 oz. - -	146.50			
Small pieces of silver from the cupelle .970 fine 115.00 oz. - -			111.5	
In market lead 0.33 oz. pr. ton in 67,104 lbs.	11.18			
" " " 0.33 " " 53.420 "			8.9	
" litharge " 30 " " 5,209 "			78.0	
Total silver obtained. - -	6,189.34		5,844.3	
Silver not recovered, - -	116.26		321.6	
	6,305.60	6,305.6	6,165.9	6,165.6
Percentage of silver obtained, -	98.1		93.3	

LEAD OBTAINED.	No. 1.		No. 2.	
	lbs.	lbs.	lbs.	lbs.
Work lead used - - - -		87,294		62,895
"Schlicker" 3,497 lbs. at 80 per ct, -	2,797			
Impure Litharge from dezincation, 3,500 lbs. at 80 per ct. lead, - - -			2,800	
Lead in zinc crust, - - - -	7,765		5,002	
Soft market lead, - - - -	67,104		53,420	
Oxides and skimmings from market kettles, 1,000 lbs. at 95 per ct. lead, - -	950			
Oxides and skimmings from market kettle, 700 lbs. at 95 per ct. lead, - -			665	
Litharge from dezincation, 7,810 lbs. at 80 per ct. lead, - - - -	6,248			
Lead from liquation, - - -	808			
Total lead, - - - -	85.672		61,887	
Loss about 1.9 per ct., - -	1.622			
" " 1.7 " - -			1,008	
	87,294	87,294	62,895	62,895

The following example of an operation at the Penn. Co.'s works has been prepared for me by Mr. J. A. Knapp, formerly the Superintendent there:

Quantity of argentiferous lead, from Utah ores, charged, -	26 tons.
Quantity of silver after dressing in the softening-furnace, -	55.94 oz.
Number of skimmings, - - - - - -	2.
Interval between skimmings, - - - - -	6 hours.
After dressing in the zinc kettle, the lead contained silver, -	57.63 oz.
After the first addition of zinc, " " " -	13.34 "
The second addition of zinc was - - - -	300 lbs.

The time between No. 1 and No. 2, - -	5 to 6 hours.
After the second addition the lead contained silver, - -	0.87 oz.
The third addition of zinc was - - - - .	150 lbs.
After the third addition the lead contained silver, - -	0.09 oz.
Number of skimmings in softening-furnace, - - -	3.
The merchant lead from the softening-furnace contained silver,	0.093 oz.

The following tables, 1, 2 and 3, have been prepared for me by Mr. E. F. Eurich, as the result of the work at the Pennsylvania Lead Company's Works, in August, 1879 :—

1. LEAD OBTAINED.

	Lbs.	Lbs.
Charged.		
Bullion, - - - - - - -		654,074
Produced—		
Metallic dross, from refining furnace, - -	11,402	
43,540 lbs. refining furnace skimmings, at 83 per cent. lead, - - - - - - -	35,138	
Metallic dross from the desilverizing kettle, -	16,290	
37,357 lbs. zinc crusts, containing - - -	32,604	
27,616 lbs. softening-furnace skimmings, at 83 per cent. lead, - - - - - - -	22,921	
Merchant lead, - - - - -	533,207	
	651,562	
Loss, - - - - - - -	2,512	
	654,074	654,074

From the above amount of bullion, there was produced 591,244 lbs. of refined bullion, ready for desilverizing.

The silver contents of merchant lead vary from $\frac{5}{100}$ to $\frac{15}{100}$ oz.

The refined bullion is desilverized with from three to four zinc additions, varying according to the richness of the bullion.

The total quantity of zinc added to effect the complete desilverizing of 591,244 lbs. refined bullion, was 7,860 lbs.

2. SILVER OBTAINED.

	Ozs.	*Fine Silver.* Ozs.
Charged—		
Silver contents of 591,244 lbs. refined bullion, -		35,048.23
Produced—		
Poured from cupelle 33,318 ozs., containing -	33,147.75	
Contained in 29,898 lbs. litharge, at 38.00 oz., -	568.06	
" " 1,302 lbs. test bottoms, - -	369.77	
" " skimmings from filling test, -	61.33	
	34,146.91	
Difference contained in dross from retorts and loss,	901.32	
	35,048.23	35,048.23

3. DISTILLATION OF THE ZINC CRUSTS.

	Lbs.	Lbs.
Charged—		
Liquated zinc crust,		37,357
Produced—		
Lead riches,	31,142	
Dross from retorts, about	2,200	
Metallic zinc, about	2,900	
Blue powder and zinc oxide, not weighed,		
Not accounted for,	1,115	
	37,375	37,375
Number of charges made,	59	
The average weight of charge,	629	
Total coke consumed,	21,000	
Quantity of coke per lb., zinc crust,	0.56	

The following tables were taken by myself from the books at Mansfield Valley, with the permission of Mr. E. F. Eurich, in June, 1880, and refer to the months of April and May of that year :—

CUPELLATION, April 1, '80.

From desilverizing kettles to retorts,		* 31,865.84
Retorts to cupelle,	31,790.08	
Extracted from 930 lbs. retort scrap,	468.81	
Retort gain,		393.05
	32,258.89	32,258.89

CUPELLATION, April, '80.

Charged 27,883 lbs. of lead riches,	30,659,58	31,790.08
Produced silver bricks shipped,	723.88	
Silver scrap,	430.08	
Litharge, 26,880 lbs., at 32 ozs.,	49.60	
Test bottoms, 400, at 248,	87.10	
Cupelle skimmings, 109 lbs.,		
Cupelle gain,		160.16
	31,950.24	31,950.24

CUPELLATION, May, '80.

From desilverizing kettles to retorts,		43,907.69
Retorts to cupelle,	43,208.76	
Extracted from retort scrap,	839.33	
Retort gain,		140.40
	44,048.09	44,048 09

CUPELLATION,, May 8, '80.

40,130 lbs. lead riches, containing		43,208.76
Silver scraps,		1,315.18
Fineness samples.		34.80
Produced silver bricks, shipped,	43,013.47	
Silver scrap,	354.35	
Contained in 398 cupelle skimmings,	261.28	
Litharge, 39,148, at 38,	743.72	
Test bottoms, 826 lbs., at 218,	90.03	
Cupelle loss,	95.89	
	44,558.74	44,558.74

* The weights are in ounces.

The following tables, taken by myself, from the books of the Company, give a summary of the work for April and May, 1880 :—

		April.	May.
Metallic dross from refining furnace, in per cent. of gross charge, - - - - - -		.078	
0.85 of lead and skimmings, - - -		2.88	2.47
1st net weight in desilverizing kettles, 1,000, -		96.34	97.53
1st crass from " " -		7.84	7.55
2d net weight " " 96.34, -	*a*	88.50	89.98
1st average assay of kettles, - - -		144.67	172.73
2d " " " - - -	*b*	132.64	160.92
1st crasses in per cent. of 1st net metal in desilverizing kettles, - - - - -	*c*	8 58	8.04
Retort in per cent. of 2d desilverizing kettles, -	*d*	7.54	8.32
Zinc used in per cent. gross charge, - -		1.37	1.59
" " 1st net weight in desilverizing kettles	*e*	1.43	1.63
" " per cent. of merchants' lead, -		1.72	1.98
Coal used per ton of gross charge, - -		192.16	208.00
" " merchant lead, - -		238.00	262.00
Lead in merchant lead, - -		90.47	88.99
" retort crasses, - - - -		6.78	7.47
" refining skimmings, - - -		3.28	3.48
		100.53	99.94

Apparent gain, 0.53 per cent , - - - Loss 1.06 per cent.
The losses and gains are apparent only.

a Charge for the retorts calculated on this. *b* Average assay. *c* Per centage of 96.34. *d* Per centage of 88.50. *e* Per centage of 96.34.

The lead made by the Germania, Pennsylvania Co. and St. Louis works is exceedingly fine. As it can be used for the manufacture of white lead, it commands the highest market price.

The following analyses, made by Dr. O. Wurth and Dr. Zuireck, on a sample from the works of the Pennsylvania Lead Company, show that the lead is equal if not superior to any of the brands produced abroad :—

In 100 parts.	Dr. O. Wurth.	Dr. Zuireck, Berlin.	Dr. O. Wurth.	Dr. Zuireck, Berlin.
Silver,	0.00042	0.00035	0.00016	0.00070
Antimony,	0.00051	0.00254	0.00318	0,00346
Copper,	0.00007	0.00094	0.00005	0.00093
Zinc,	0.00038	0.00070	0.00122	0.00075
Iron,	trace.	0.00082	0.00013	0.00082
Sulphur,	0.00018	———	0.00023	———
Arsenic,	none.	———	trace	———
Bismuth,	———	0.03843	0.02746	0.04594

In conclusion, I beg to express my thanks to Mr. Faber du Faur, for working-drawings of his furnaces, to Mr. Weisse, of the Germania Works, and to Mr. Eurich, of the Pennsylvania Works, for the many interesting details furnished me by them while visiting their works for the preparation of this article.

LIST OF FIGURES.

V.—*Description of a New Species of Triodopsis, from New Mexico.*

BY THOMAS BLAND.

Read November 22d, 1880.

Triodopsis Levettei, nov. sp.

Testa umbilicata, orbiculato-convexa, tenuis, nitens, translucens, leviter et irregulariter oblique striata, castanea, superne pallescens ; spira vix elevata, apice obtusa ; sutura impressa ; anfr. 7 convexiusculi, lente accrescentes, ultimus antice breviter depressus, spiraliter subobsolete striatus, pone aperturam constrictus, subscrobiculatus, basi subconvexus; umbilicus mediocris ($\frac{1}{8}$ diametri), pervius; apertura perobliqua, subcircularis, dente albo, valido, flexuoso, transverso, in pariete aperturali intrante coarctata ; peristoma reflexum, pallide castaneum, intus callosum, marginibus callo tenuissimo junctis, margine dextro dente albo, obtuso, erecto, submarginali, basali dentibus duobus, albis, transversis, supero majore, instructo.

Diam. maj. 16, min. 15, alt. $6\frac{1}{2}$; apert., perist. incluso, long. 7, lat. 8 mill.

Triodopsis Levettei, nat. size.

Shell umbilicate, orbiculate-convex, thin, shining, translucent, slightly and irregularly obliquely striated, chestnut colored, the upper whorls paler;

spire scarcely elevated, apex obtuse ; suture impressed ; whorls 7, rather convex, gradually increasing ; the last somewhat depressed at the aperture, obsoletely spirally striated, constricted behind the aperture, and slightly scrobiculated, base sub-convex ; umbilicus moderate, $\frac{1}{8}$ diameter of the shell, pervious ; aperture very oblique, sub-circular, with a well developed flexuose, transverse white tooth on the parietal wall ; peristome reflected, pale chestnut colored, thickened within, the margins joined by a slight callus, the right margin with a white, obtuse, erect, submarginal tooth, the basal margin with two white transverse teeth, the upper one the larger.

Habitat, near Santa Fé, New Mexico, where two living and one dead specimen were collected by my friend, Dr. G. M. Levette, who presented to me one of the former. Cabinet of Dr. Levette, and the Binney and Bland collection in the American Museum of Natural History, New York.

Remarks.—This species is quite distinct from any known North American or other form. The number of whorls, and of teeth, their form and color, with the color of the shell and peristome, are its peculiar features. The striæ are by no means so well developed as shown in the figures.

VII.—*On the Relations of the Flora and Fauna of Santa Cruz, West Indies.*

BY THOMAS BLAND.

Read January 3d, 1881.

Professor A. Agassiz (Bull. Mus. Comp. Zool., Cambridge, V, Nos. 14, 289, June, 1879) remarks, "One of the most interesting results reached by this year's cruise, is the light thrown upon the former extension of the South American Continent, by the soundings taken while dredging, and those subsequently made in the passages between the islands by Commander Bartlett. These, together with the soundings already known, enable us to trace the outline of the old continent with tolerable accuracy, and thus obtain some intelligible, and at the same time trustworthy, explanation of the peculiar geographical distribution of the fauna and flora of the West India Islands."

Professor Agassiz writes (l. c.): "In attempting to reconstruct, from the soundings, the state of things existing in a former period, we are at once struck by the fact, that the Virgin Islands are the outcroppings of an extensive bank. The greatest depth between these islands is less than forty fathoms, this same depth being found on the bank to the east of Porto Rico, the 100-fathom line forming, in fact, the outline of a large island, which would include the whole of the Virgin Islands, the whole of Porto Rico, and extend some way into the Mona Passage." * * "On examining the 500-fathom line, we thus find that Jamaica is only the northern spit of a gigantic promontory, which once extended toward Hayti from the mainland, reaching from Costa Rica to the northern part of the Mosquito coast, and leaving but a comparatively narrow passage between it and the 500-fathom line encircling Hayti, Porto Rico, and the Virgin Islands, in one gigantic island. The passage between Cuba and Jamaica has a depth of 3,000 fathoms, and that between Hayti and Cuba is not less than 873 fathoms, the latter being probably an arm of the Atlantic. The 500-fathom line

connects, as a gigantic island, the banks uniting Anguilla to St. Bartholomew, Saba Bank, the one connecting St. Eustatius to Nevis, Barbuda to Antigua, and from thence extends south so as to include Guadeloupe, Marie-Galante, and Dominica. This 500-fathom line thus forms one gigantic island of the northern islands, extending from Saba Bank to Santa Cruz, and leaving but a narrow channel between it and the eastern end of the 500-fathom line running round Santa Cruz. As Santa Cruz is separated from St. Thomas by a channel of forty miles, with a maximum depth of over 2,400 fathoms, this plainly shows its connection with the northern islands of the Caribbean group, rather than with St. Thomas, as is also well shown by the geographical relations of its mollusca."

Professor Agassiz gives (l. c.) an extract of a letter addressed to him by Commander Bartlett, from which I quote the following:—"I finished up the line connecting Saba Bank with St. Croix. I found the connection perfect, but the ridge has 700 fathoms water on it near St. Croix. There is 1,000 fathoms three miles north, and 1,800 fathoms five miles south of the ridge."

Professor Agassiz refers to the connection of Santa Cruz "with the northern islands of the Caribbean group, rather than with St. Thomas." As he bases his argument on the deep channel which separates Santa Cruz from St. Thomas, I judge that he excludes the Virgin Islands, of which St. Thomas is one, from the Caribbean group. In that case, in his view, Sombrero, Anguilla, St. Martin and St. Bartholomew (the three latter on the Anguilla Bank) and Saba (the Saba Bank connected by a ridge with Santa Cruz), are the "northern islands," to which the Professor alludes.

In my paper "On the Physical Geography of, and the Distribution of Terrestrial Mollusca in the Bahama Islands" (Ann. N. Y. Lyc., X, 1873, 320), after quoting some of the views of Professor Dana, expressed in his work, "Corals and Coral Islands," 1872, I wrote as follows:—

"The facts regarding the diminution in size of the islands of the West Indies to the eastward, are of peculiar interest, not only as affording conclusive evidence of the greater subsidence in that direction, but in connection with geographical distribution."

"The banks and islands forming the long Bahama chain diminish in size to the southeast, where are situated at its termination the submerged Mouchoir Carré, Silver and Navidad Banks. In a similar manner, the submerged Virgin Island Bank (with Anegada on its northeastern extremity, geologically, in the opinion of Dr. Cleve, resembling the Bahamas), Sombrero and the Anguilla Bank, terminate the chain of the West Indies (parallel with the Bahamas) eastward from Cuba."

In a previous paper (Proc. Amer. Phil. Soc., 1871, 57) I endeavored to show, that the land-shell fauna of Porto Rico, with Viéque, the Virgin Islands, Sombrero, Anguilla, St. Martin, St. Bartholomew and Santa Cruz, is unquestionably the same.

My present object is to show that Santa Cruz is connected with St. Thomas, the fauna of both derived from Porto Rico, in common with that of Sombrero and the islands on the Anguilla bank, but by no means with Saba.

Before discussing the statement of Prof. Agassiz as to the connection of Santa Cruz with the northern islands of the Caribbean group rather than with St. Thomas (of the Virgin group), I would first shortly describe the general features of the geology of Santa Cruz, and the character of its flora.

Dr. P. T. Cleve (Proc. Royal Swedish Acad. of Sciences, Stockholm, 1871) remarks :—"The geological formations of the Island belong to different ages. The northern mountain ridge is the oldest, and to judge from its great petrographical resemblance with the rocks of the Virgin Islands, it would seem to belong to the same geological age as the latter, or the cretaceous. Upon those highly disturbed strata, very little disturbed beds of coralline limestone and white marls rest; they are probably of the miocene age. The youngest formation consists of detritus swept down from the mountains by rains and mixed with the white marls, and in a recent formation of calcareous sand around the shores." * * *

"The recent formations of the island are partly terrestrial, partly marine. The former covers a great deal of the surface of the island in the plains below the mountains. It consists of detritus and clay, sometimes mixed with white marl. In this detrital mass are found shells of terrestrial mollusca, some of which are of extinct species and some no more extant in St.

Croix, but found living in the islands of Viéque, and Puerto Rico."

To Baron H. F. A. Eggers, scientists are indebted for an extremely valuable paper on "The Flora of St. Croix and the Virgin Islands" (Bulletin U. S. Nat. Mus., No. 13; Washington, 1879), from which I offer extracts. The distribution of the plants has an important bearing on that of the terrestrial mollusca, and the evidence to be derived therefrom as to the former faunal connections of Santa Cruz.

Baron Eggers remarks:—"Looking at the vegetation of St. Croix and the Virgin Islands in its generality, and without entering into details, we may consider it to be identical, showing the same main features." * * * "Yet, in looking more closely into details, we are soon struck by finding a great many species in the one which are not found in the other."

Referring to the list of plants given in his paper, it will be seen, the author says, that "out of a number of 881 indigenous phanerogamous species no less than 215, or c. $\frac{1}{4}$, are found in the Virgin Islands only, whilst 98, or about $\frac{1}{9}$, occur only in St. Croix, thus leaving only 568, or less than $\frac{2}{3}$, common to both." He adds, that it is "in the forest vegetation, which best represents the original flora of the islands, that the greatest and most varied differences are observed, showing especially the great variety of species in the Virgin Islands which are not at all found in St. Croix, and among which are many of the commonest and most generally distributed forms." * * *

"However great are the differences in the flora on the two groups of islands, yet this interesting fact is not due to their possessing endemic species, as all the plants known as growing on them are also found in other West India Islands, especially Porto Rico, whence the vegetation of both the Virgin Islands and St. Croix seems to be derived."

With respect to the question, "Why is it that St. Croix, although the largest of all, has received a comparatively and absolutely much less number of species than, for instance, the far smaller St. Thomas?" Baron Eggers offers the following solution:—"I am thus led to think that, at a former period, all the West India islands have been connected mutually, and perhaps with a part of the American continent also, during which time

the plants in common to all the islands, as well as to the West Indies and the continent, have expanded themselves over their present geographical areas, at least as far as they are not possessed of particular faculties for emigration over the sea. By a subsequent volcanic revolution, St. Croix, as well as many of the other islands, has thereafter been separated from Porto Rico and the Virgin Islands, and put into its present isolated position, which it seems to have retained ever since, whilst the latter group of islands has either still, for a long period, remained in connection with Porto Rico, or, if separated at the same time from it as St. Croix, has, by another revolution, been again connected with the former."

As to the plants now living in Santa Cruz, which have not been found in the Virgin Islands, Baron Eggers desires it to be understood, that whilst his investigations of Santa Cruz have been thorough, his explorations have been less complete, and he feels confident that not a few of such plants may, by closer research, still be discovered in the latter.

I propose, now, to examine the character of the terrestrial mollusca of Santa Cruz, and the evidence which they offer as to the connection of that island with others in its vicinity.

The most important feature is the number of species found semi-fossil only,—several extinct, others still living elsewhere: of the whole, I add the following list.

Semi-fossil species, extinct.

? *Chondropoma basicarinatum*, Pfr.
" *chordiferum*, "

The latter, perhaps, a variety of the former.

C. Santacruzense, Pfr., now living in Santa Cruz and St. Thomas, is of much the same type, and may be considered the living representative of *C. basicarinatum*.

In Malac. Blatt., xxi, p. 173, D. F. Weinland described a fossil, from Menke's collection, attributed to Hayti, as *Cyclostoma* (*Tudora?*) *Kazika*. He sent to me a specimen of it, and I forwarded to him the Santa Cruz fossil (*C. basicarinatum*), which he considers the same, the habitat Hayti of Menke being erroneous (Jahrb., vii, 1880).

Thelidomus incerta, Fér. This occurs, also semi-fossil, in St. Thomas;—its nearest ally is *T. notabilis*, Shuttl. of St. Jan and Tortola.

Plagioptycha Santacruzensis, Pfr. Allied closely to *P. nemoralina*, Pet., of St. Thomas, St. Jan and Tortola.

Bulimulus extinctus, Pfr. Near to *B. elongatus*, Bolt., which inhabits Porto Rico, the Virgin Islands, islands on the Anguilla Bank, several of the northern Caribbees, Curaçao and Buen Ayre.

Bulimulus Riisei, Pfr. This can scarcely be compared with any known West Indian form.

Strophia rudis, Pfr. var. *latilabris*, Pfr. Allied to species now living in Porto Rico and in several of the eastern Virgin Islands.

Semi-fossil Species, extinct in Santa Cruz, but living elsewhere.

Chondropoma Tortolense, Pfr. A specimen from Santa Cruz, in my cabinet, I referred to this species, which now inhabits Tortola and several of the more eastern Virgin Islands.

Caracolus caracolla, L. This species is found living in Porto Rico and Viéque; it is nearly allied to *C. sarcocheila*, Morch, *C. insititia*, Shuttl, and *C. excellens*, Pf., of Hayti.

In my Catalogue, Ann. N. Y. Lyc., vii, 1861, I included *C. marginella*, Gmel., as occurring semi-fossil in Santa Cruz, but erroneously, as I was assured by the late Mr. Robert Swift.

Succinea approximans Shuttl.—I referred a specimen in my cabinet to this species, which occurs in Porto Rico, the Virgin Islands, and several of the Caribbees.

SPECIES NOW LIVING IN, AND PECULIAR TO, SANTA CRUZ.

Cistula rufilabris, Beck.—Allied in many respects to *Chondropoma Julieni*, Pfr. of Sombrero.

Cylindrella chordata, Pfr. (*Trachelia.*)

SPECIES NOW LIVING IN SANTA CRUZ AND ELSEWHERE.

Chondropoma Santa-cruzense, Pfr.

* *Microphysa vortex*, Pfr. Also, St. Thomas.

* *Bulimulus fraterculus*, Fér.

* *B. elongatus*, Bolt.

* *B. marginatus*, Say.

* *Pupa pellucida*, Pfr.

* *Succinea Riisei*, Pfr.

With regard to the genera of the semi-fossil species, I may remark, *Thelidomus* is characteristic of Cuba and Jamaica, is represented in Porto Rico and the Virgin Islands, but has one species only in the Caribbees, *T. discolor*, Fér.

Plagioptycha belongs to Hayti, and *Caracolus* to Cuba and Hayti, with a representative in Porto Rico, but neither in the Caribbees.

Strophia, with numerous species in Cuba and the Bahamas, several in Hayti, Porto Rico and the Virgin Islands, does not occur in the Caribbees. One species, however, lives in Curaçao and Buen Ayre. The impression only of a species, is found in the phosphatic lime-rocks of Sombrero.

* These species, more or less widely distributed, cannot be said to be characteristic of the faunas of any of the islands.

The discovery of a submarine ridge, connecting Santa Cruz with Saba is interesting; but its geological age is as uncertain as is that of the deep chasm now separating Santa Cruz from St. Thomas.

I have shown, conclusively, I think, that the land-shells supply abundant evidence of the former connection of Santa Cruz with St. Thomas, and the other islands of the Virgin group, but none of its connection with Saba.

A variety of *B. fraterculus* occurs in Saba, and a *Succinea*, which I believe to be *Riisei*, with several of the widely distributed *Stenogyræ*, and *Helicina picta*, Fér., belonging to the Caribbean fauna, is also found there. Very recently I have received from thence, through the kindness of my friend, Mr. F. A. Ober, many specimens of *Amphibulima patula*, Brug., hitherto known only from St. Christopher, Dominica and Marie-Galante.

The five-hundred-fathom line mentioned, embraces Anguilla, St. Martin, and St. Bartholomew, but their land-shells are far more allied to those of Porto Rico and the Virgin Islands than to Caribbean species. *Macroceramus signatus*, Guild., occurs in Anguilla and St. Bartholomew, in several of the Virgin Islands, and in Hayti,—the genus is not represented in the Caribbees.

Pineria Schrammi, Fisch., of Guadeloupe, which I believe to be identical with *P. Viequensis*, Pfr., of Viéque and Barbados, inhabits each of the three islands on the Anguilla bank.

With regard to changes of the flora and fauna of Santa Cruz, two causes have been suggested, but entirely under misapprehension, and I deem it desirable to place the facts on record.

The Rev. John P. Knox, in his "Historical Account of St. Thomas, W. I." (New York, 1852), relates circumstances connected with the establishment of a French colony in Santa Cruz, in 1650. The settlement, he says, proved at once very unhealthy. He adds:—"In order to arrest the mortality which was so rapidly thinning their numbers,—a mortality which arose from the dense and aged forests that covered the island, scarcely affording an opportunity for the winds to carry off the poisonous vapors with which its morasses clogged the atmosphere,—

the colonists who remained, set fire to the woods, and, going on board their ships, became spectators of the conflagration. They returned on shore after the flames were extinguished."

Mr. Alfred Newton, in "Observations on the Birds of St. Croix" (*Ibis*, I, 59, 1859). quotes Knox's account of the conflagration, and in his remarks rather amplifies it.

"That the simultaneous and sudden destruction by fire of all the woods on an island like this, would have a marked and lasting effect upon its fauna, no one can doubt; and one of its results may probably be traced in a fact ascertained by Herr Apothek Riise, of St. Thomas, that in St. Croix there occur the dead shells of about a dozen species of terrestrial molluscs, of which he has never found a single example inhabited by the living animal, though they are undoubtedly recent and not fossil forms. It is difficult to account for the extinction of so many species, unless it may be presumed that the changes brought about in the island by so great a fire, rendered it unsuitable for their longer habitation."

I called the attention of Baron Eggers to this subject, and he entirely discredits any such general conflagration. He informed me, that old Pére Labat, when in 1700 he visited the island, after its having been given up and abandoned by the French in 1676, found it entirely covered with wood, as did also the first Danish settlers who, in 1739, went over there to found their plantations.

The destruction of the species of mollusca referred to, must rather be attributed to geological changes.

In the Bulletin of the Torrey Botanical Club (N. Y., IV, No. 2, July, 1873), a communication appeared from Mr. F. Hubbard, on the subject of the desiccation of Santa Cruz. He wrote:—"At my former visit, twenty-seven years ago, the dessication (of Santa Cruz) had undoubtedly made some progress, but it had not been sufficient to make itself manifest in a very marked degree. The change from fertility to barrenness, which at first must have been almost imperceptible, is no doubt taking place in an accelerating ratio." He adds:—"The final depopulation of this beautiful island seems now to be written indelibly among the decrees of fate."

Baron Eggers informs me, that the year 1873 was an uncommonly dry one, as had been, also, 1872, and as was 1874. The effect of the drought was, he says, very plainly to be seen, but since, there have been not less than three or four very wet years, and the island at present (March, 1880) is as green as ever.

Baron Eggers remarks :—"There can be no doubt that, compared with St. Thomas, Santa Cruz is more favored with moisture than the reverse; its forests are still of some extent, and trees are not removed in the latter as in former times, when the land was continually cleared more and more to satisfy the increasing demand for sugar."

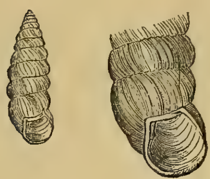
At the end of last century, he says, there were 27,000 acres in cane cultivation, now there are only 17,000. The difference of 10,000 acres is again overgrown with trees, shrubs, grass, etc.

The so-called desiccation of the island of Santa Cruz can, in fact, be no more accepted than the conflagration caused by the French colonists, as sufficient sensibly to affect its flora or fauna.

VIII.—*Notes on Macroceramus Kieneri, Pfr. and M. pontificus, Gould.*

BY THOMAS BLAND.

Read January 24th, 1881.



Macroceramus Kieneri, Pfr.

Dr. Pfeiffer described *Macroceramus Kieneri* as a *Bulimus*, in Proc. Zool. Soc., 1846, and later, in Mon. Hel. Viv., II, 79, 1848, as follows:

T. breviter rimata, cylindraceo-turrita, tenuis, oblique confertim costata, fusco-corneo et albido irregulariter marmorata; spira turrita, apice acutiusculo nigricans; sutura profunda, crenata; anfr. 13 convexi, ultimus ¼ longitudinis subæquans, basi obsolete unicarinatus; apertura lunato-circularis; perist. simplex, undique expansum, marginibus conniventibus, dextro valde arcuato, columellari dilatato, patente.

Long. 18, diam. anfr. antepenult. 6 mill. Ap. 4½ mill. longa, 4½ lata. Habitat in Honduras.

In the Proc. Boston Soc. N. H., III, 1848, Dr. Gould described *Pupa pontifica,* and the following description is given of the species, as *Cylindrella pontifica,* in Terr. Moll., II, 306, Plate LXIX, fig. 1.

Shell fusiform, attenuated-cylindrical, whitish, or grayish clouded and marbled with brown; spire acuminate; whorls from 9 to 12, rounded, with numerous oblique, prominent striæ, or ribs; suture impressed, crenulated by the extension of the alternate ribs across it; aperture rounded, oblique; lip thin, somewhat reflected; axis impressed, not truly perforate. On the last whorl, a colored line revolves: this is sometimes raised a little from the surface, and sometimes is sharp like a delicate carina.

Extreme length, half an inch ; extreme diameter, $\frac{1}{5}$ of an inch ; ordinary size less.

Pfeiffer, in Mon. III and IV, places *C. pontifica*, Gld., in the Syn. of his species. In Mon. VI and VIII, he, treating his species as a *Macroceramus*, separates it from Gould's, assigning Florida and Orizaba, Mexico, as the habitats of the latter.

Binney and Bland, in Smith. Misc. Coll., 1869, and W. G. Binney, in Terr. Moll., V, 1878, following Pfeiffer's earlier opinions, described *M. Kieneri* as a United States species, with Gould's species in its synonymy.

Crosse and Fischer (Moll. Terr. Mex., p. 423, 1873) treated *M. pontificus*, Gould,—as I have shown Pfeiffer to have done in his later works,—as distinct from *M. Kieneri*, the latter from Honduras, and the former from Orizaba (Mexico), as well as Florida and the Florida Keys.

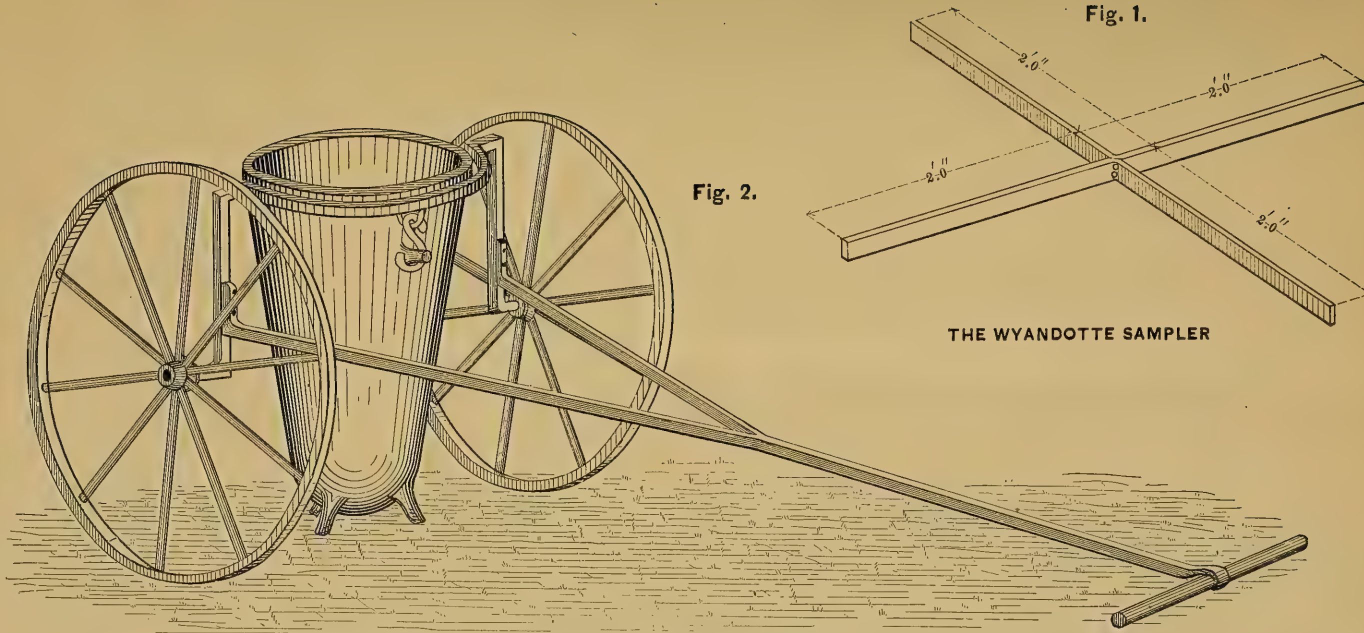
Crosse and Fischer (l. c.) describe *M. pontificus* as follows :

Testa ovato-fusiformis, superne attenuata, albida, griseo et fusco marmorata ; sutura impressa, crenulata ; anfr. 12 rotundati, costulis crebris, obliquis, alternatim suturam praetcriuntibus ornati, ultimus subcarinatus ; apertura lateralis, circularis, campanulata ; columella recta, umbilicum linearem tegens ; perist. reflexiusculum, albidum. Longitudo 18 mill., diam. maj. 6 mill. Apertura $4\frac{1}{2}$ mill. longa, $4\frac{1}{2}$ lata.

In some uncertainty as to the two species, I wrote to my friend Dr. Hy. Dohrn, the possessor of the late Dr. Pfeiffer's collection, asking if he conld furnish me with an authentic specimen of *M. Kieneri*. In the latter part of 1879, Dr. Dohrn informed me, that in Pfeiffer's collection he found three adult and one young specimen of *M. Kieneri*, and very kindly sent to me one of the adults, which the foregoing figures represent, the left hand figure being of the natural size.

It is certain that the species *M. Kieneri* does not belong to the fauna of the United States.

Fig. 1.



THE WYANDOTTE SAMPLER

Fig. 2.

PERSPECTIVE SKETCH OF THE SLAG BUGGY AT CHELTENHAM

PLATE III.

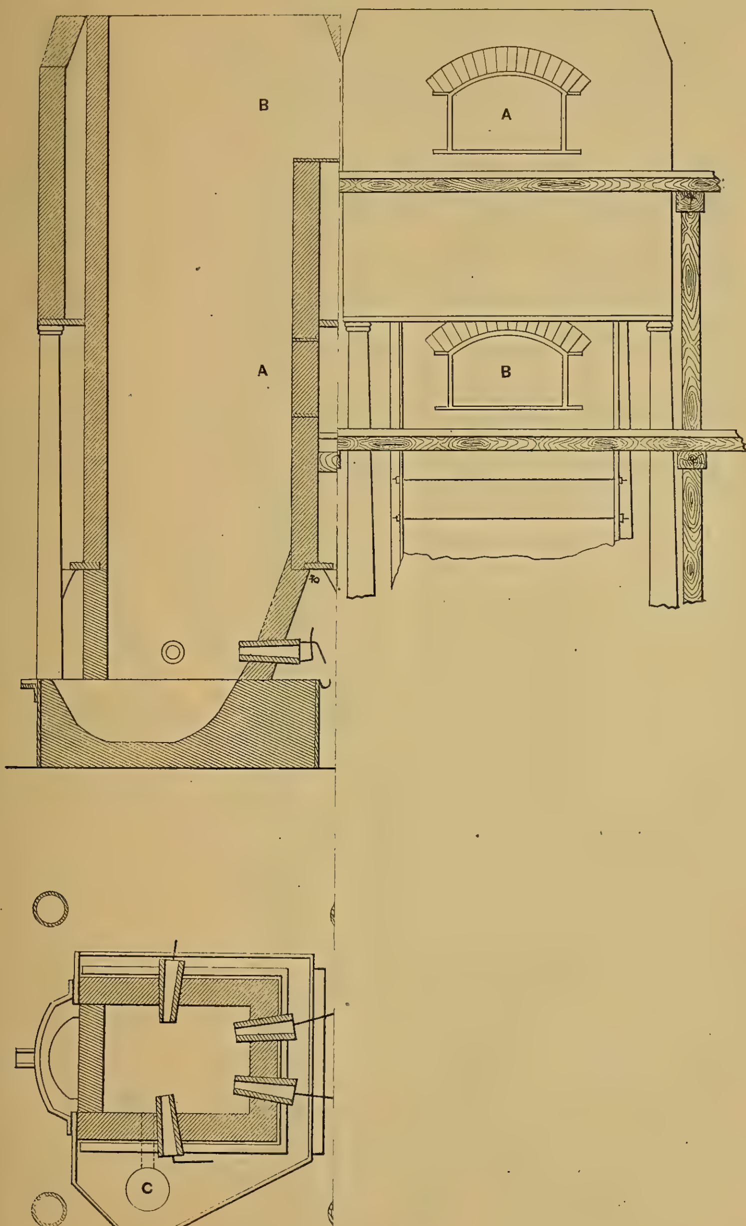
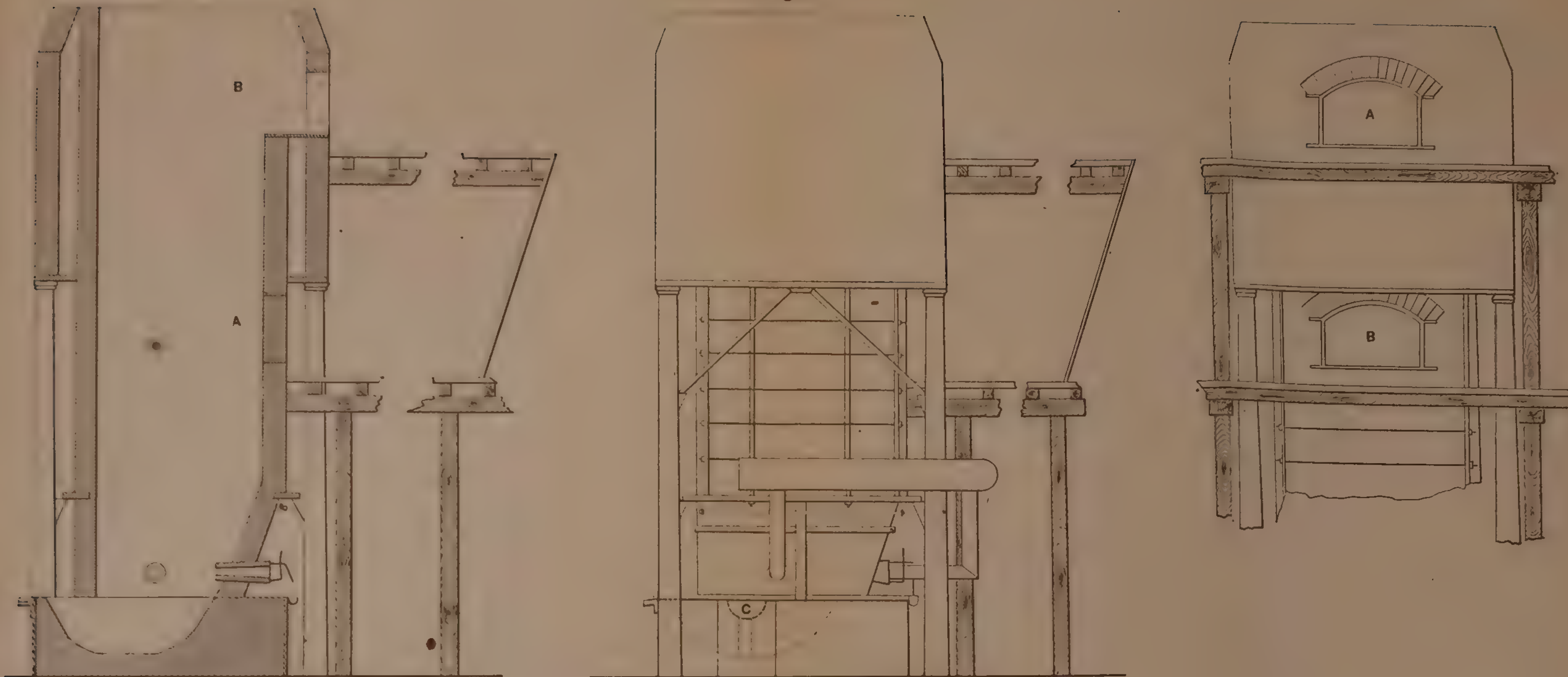
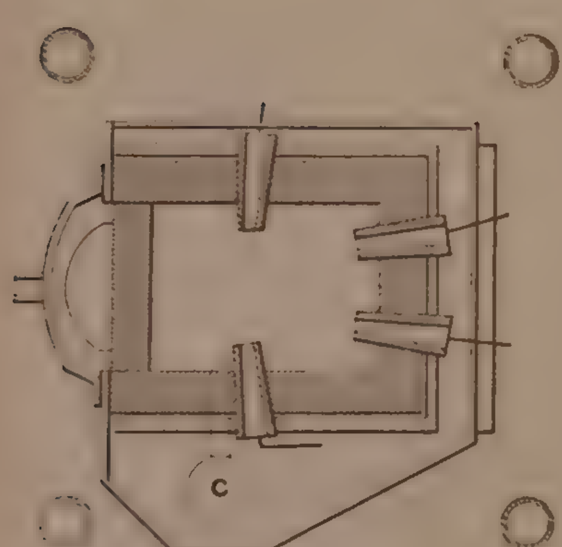

B
A
A
B
C

Fig.3.





BLAST FURNACE NO.2.

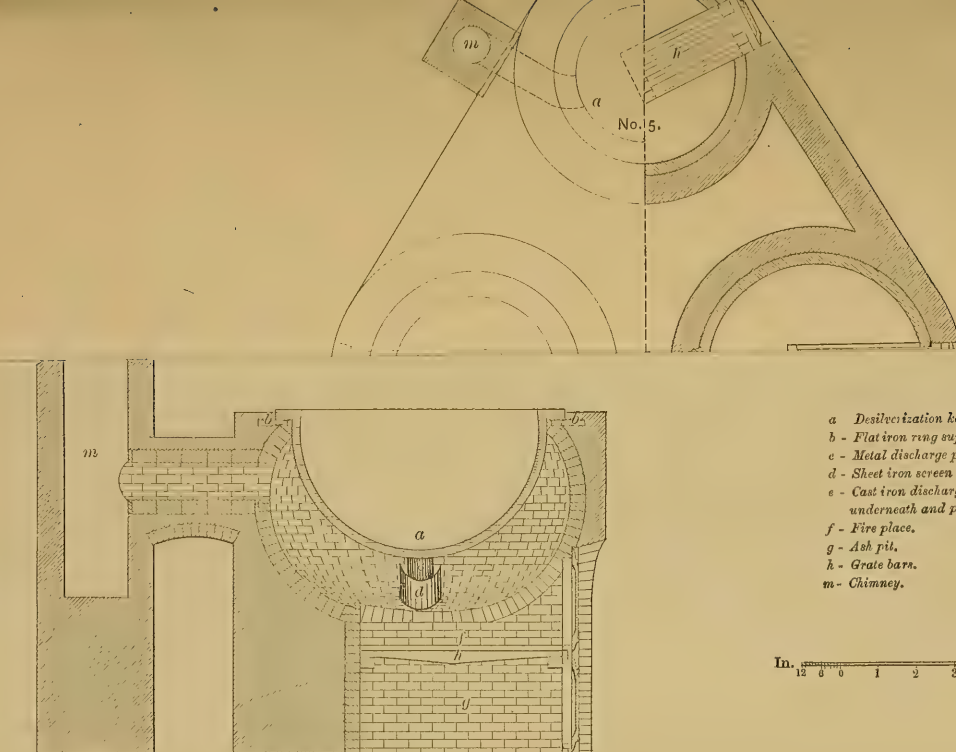
PENN. LEAD WORKS.

Scale of Feet.

0 1 2 3 4 5 10

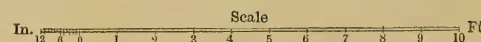
PLATE IV.

Fig. 4.



SECTION ON LINE B—B

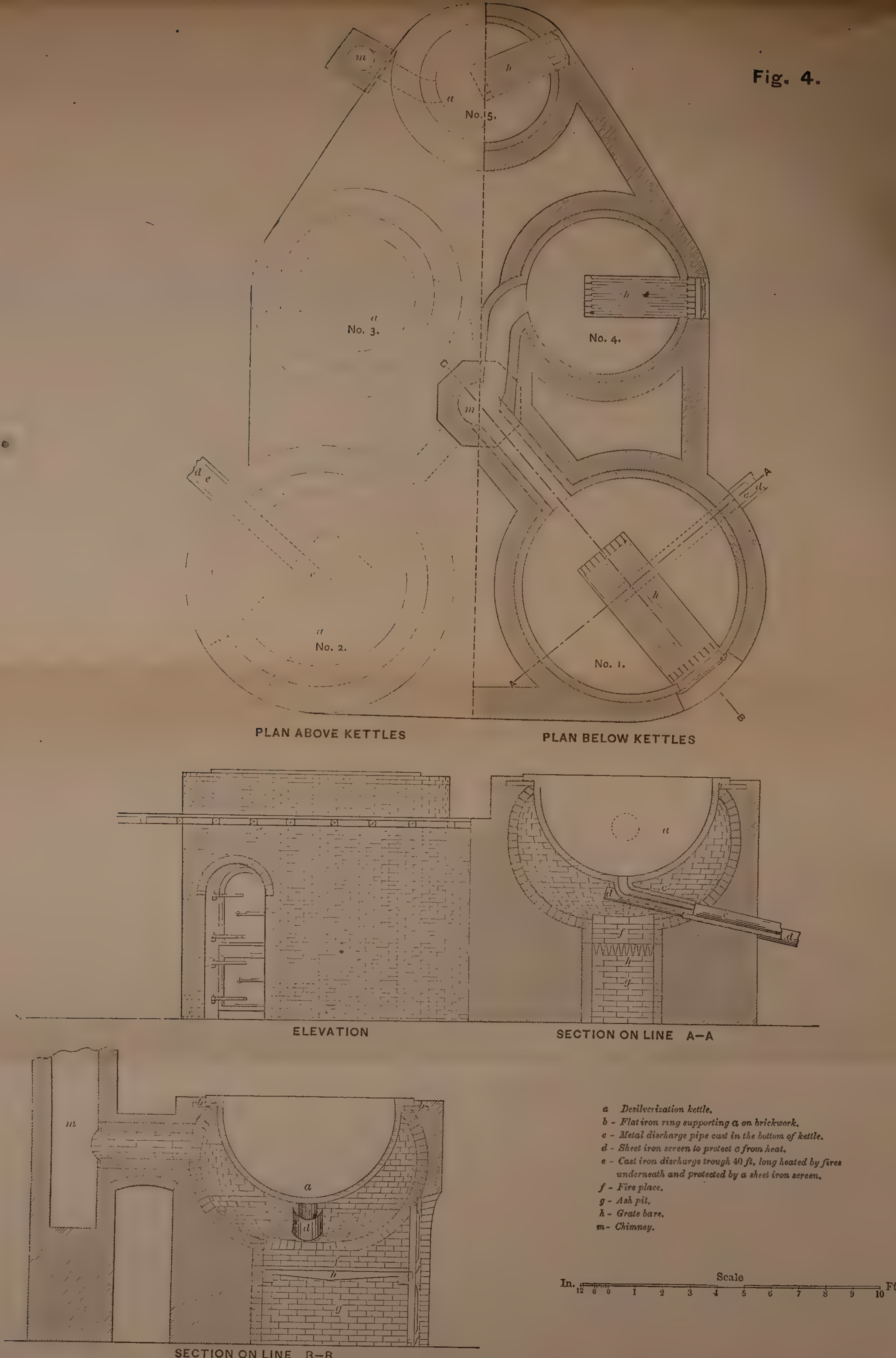
a Desilverization kettle.
b - Flat iron ring supporting *a* on brickwork.
c - Metal discharge pipe cast in the bottom of kettle.
d - Sheet iron screen to protect *c* from heat.
e - Cast iron discharge trough 40 ft. long heated by fires underneath and protected by a sheet iron screen.
f - Fire place.
g - Ash pit.
h - Grate bars.
m - Chimney.



DESILVERIZATION KETTLES AT THE GERMANIA WORKS, FLACH'S STATION, NEAR SALT LAKE, UTAH.

PLATE V.

Fig. 4.



DESILVERIZATION KETTLES AT THE GERMANIA WORKS, FLACH'S STATION, NEAR SALT LAKE, UTAH.

PLATE V.

LEAD REFINING FURNACE,

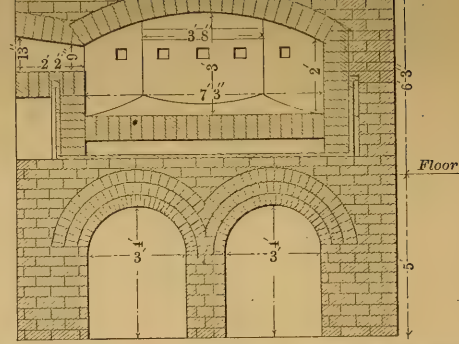
AND MARKET KETTLE.

Holding from 18 to 19 tons.

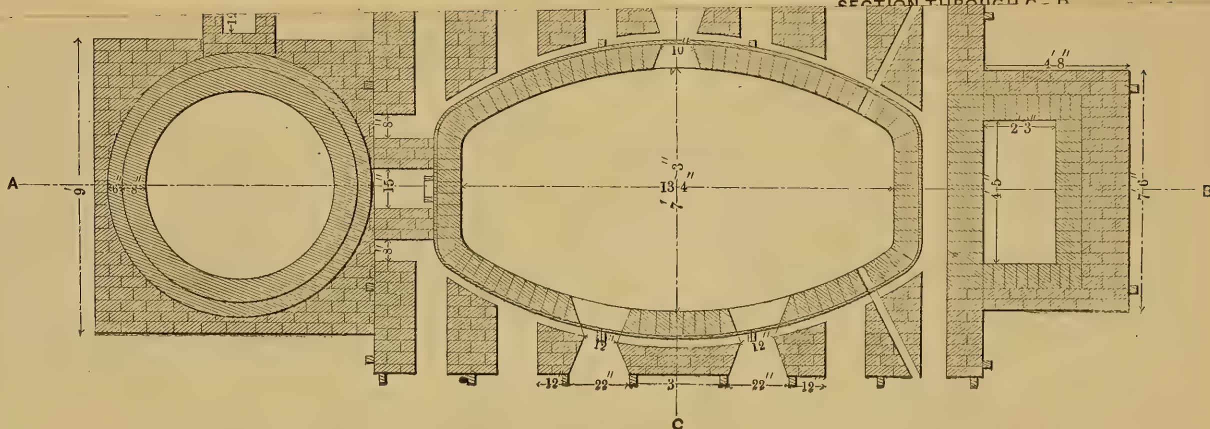
AT GERMANIA WORKS, UTAH.

SCALE

In. 12 6 0 1 2 3 4 5 6 7 8 9 10 Ft.



SECTION THROUGH C – D



PLAN.

PLATE VI.

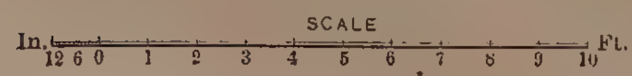
Fig. 5.

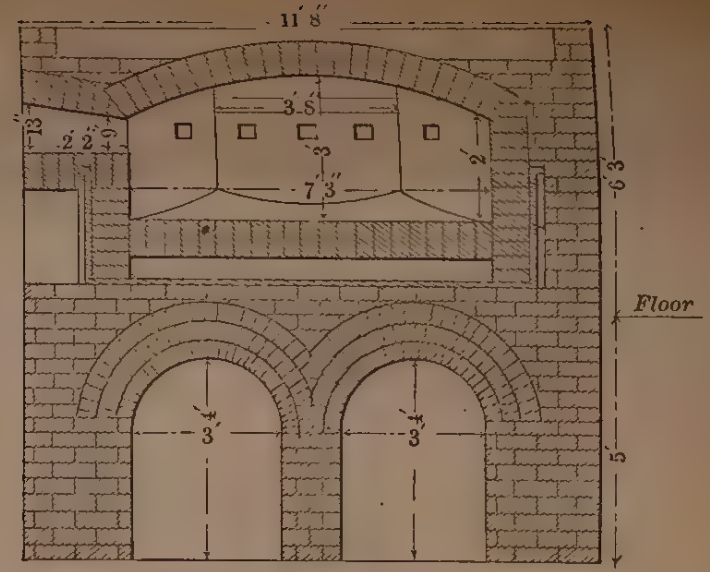
LEAD REFINING FURNACE,

AND MARKET KETTLE.

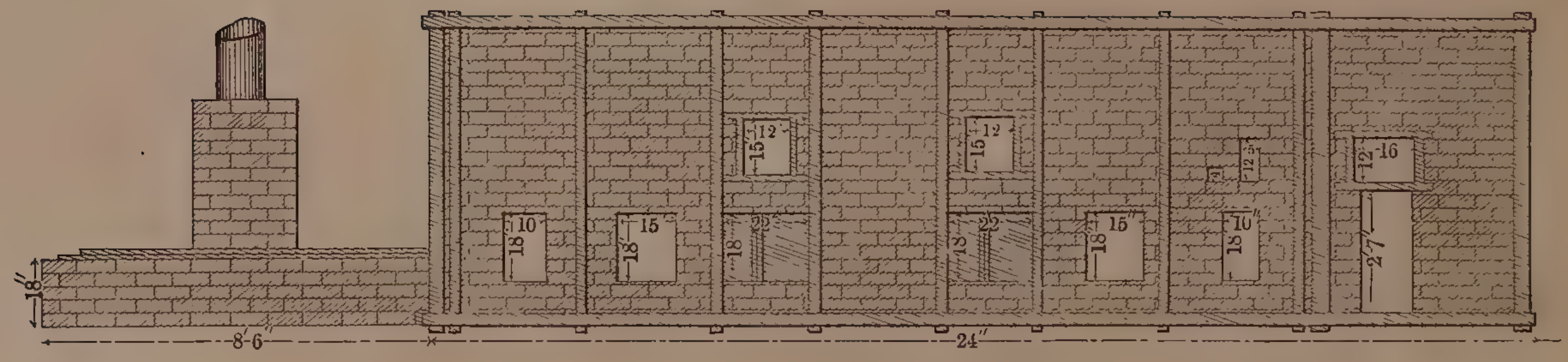
Holding from 18 to 19 tons.

AT GERMANIA WORKS, UTAH.

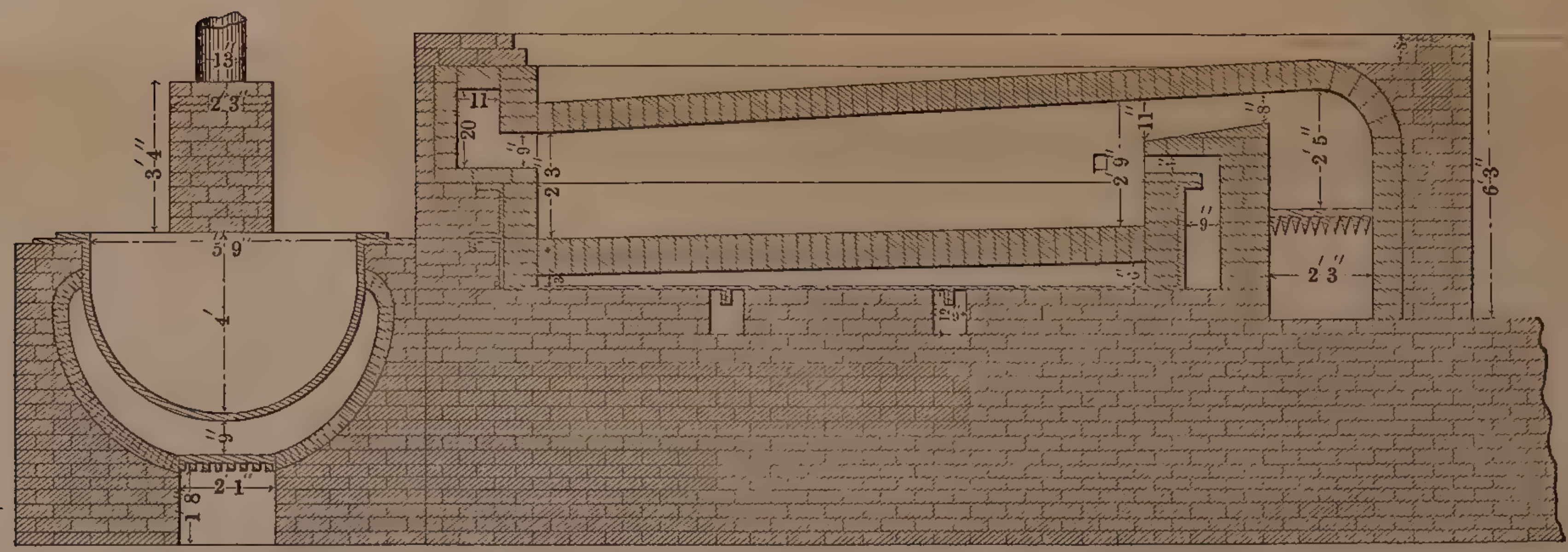




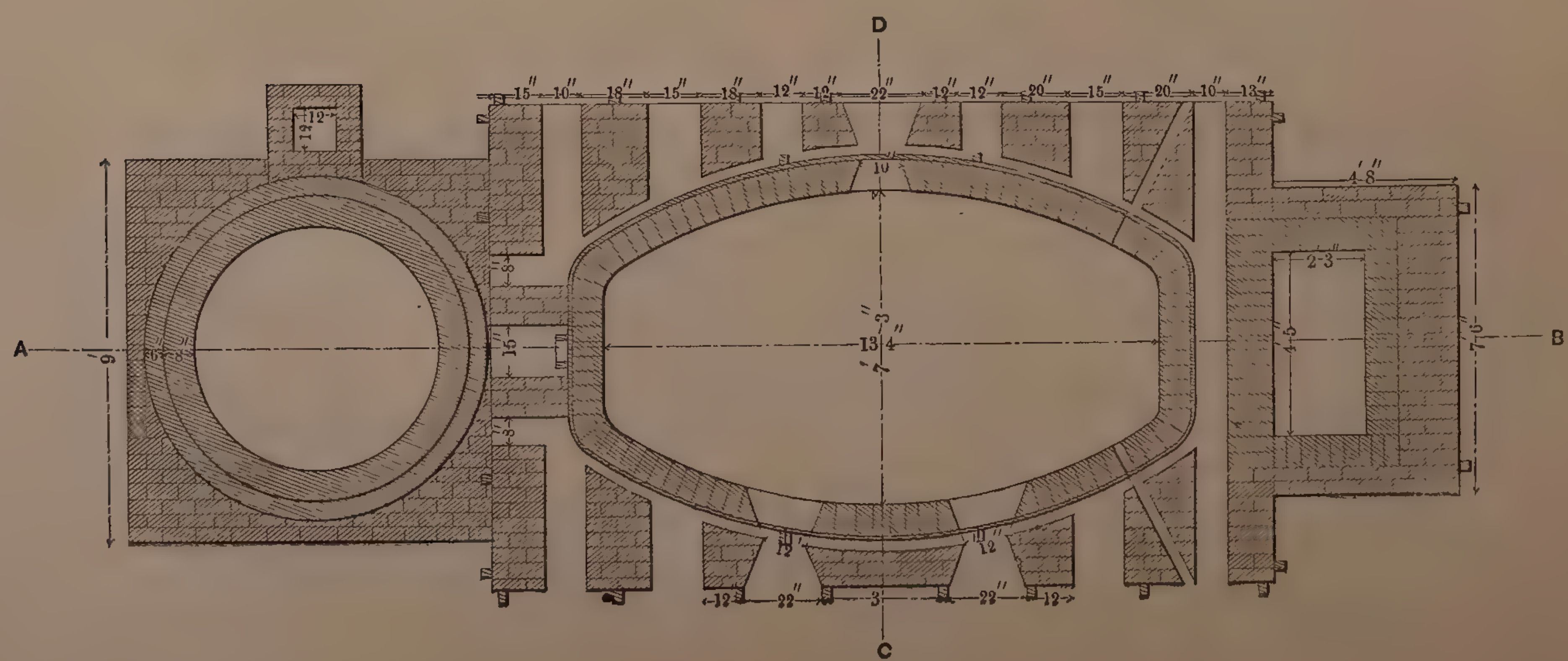
SECTION THROUGH C.--D.



ELEVATION



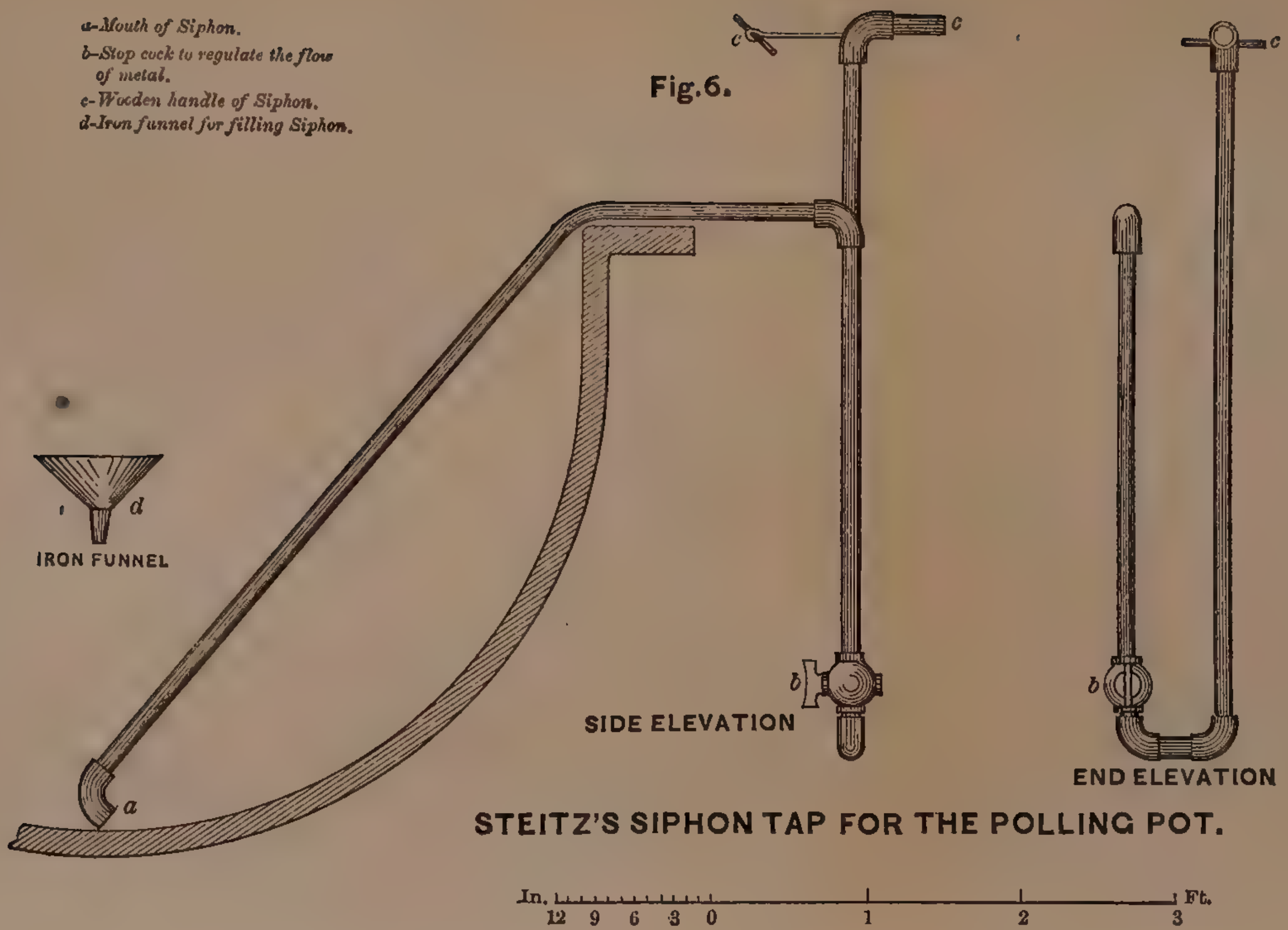
SECTION THROUGH A.--B.



PLAN.

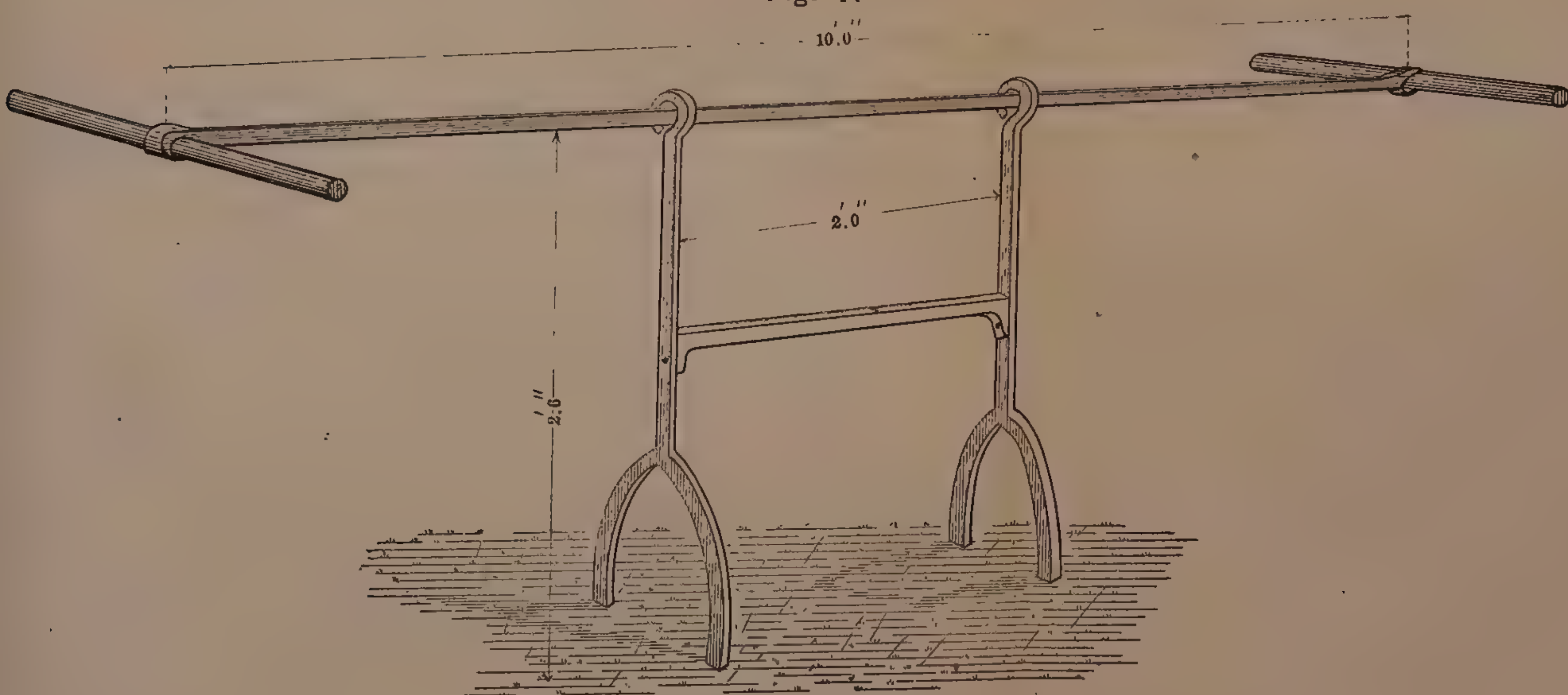
Plate VI.

Fig.6.



STEITZ'S SIPHON TAP FOR THE POLLING POT.

Fig. 7.



POLLING CRUTCH OR
WOOD-HOLDER FOR THE POLLING POTS

PLATE VII.

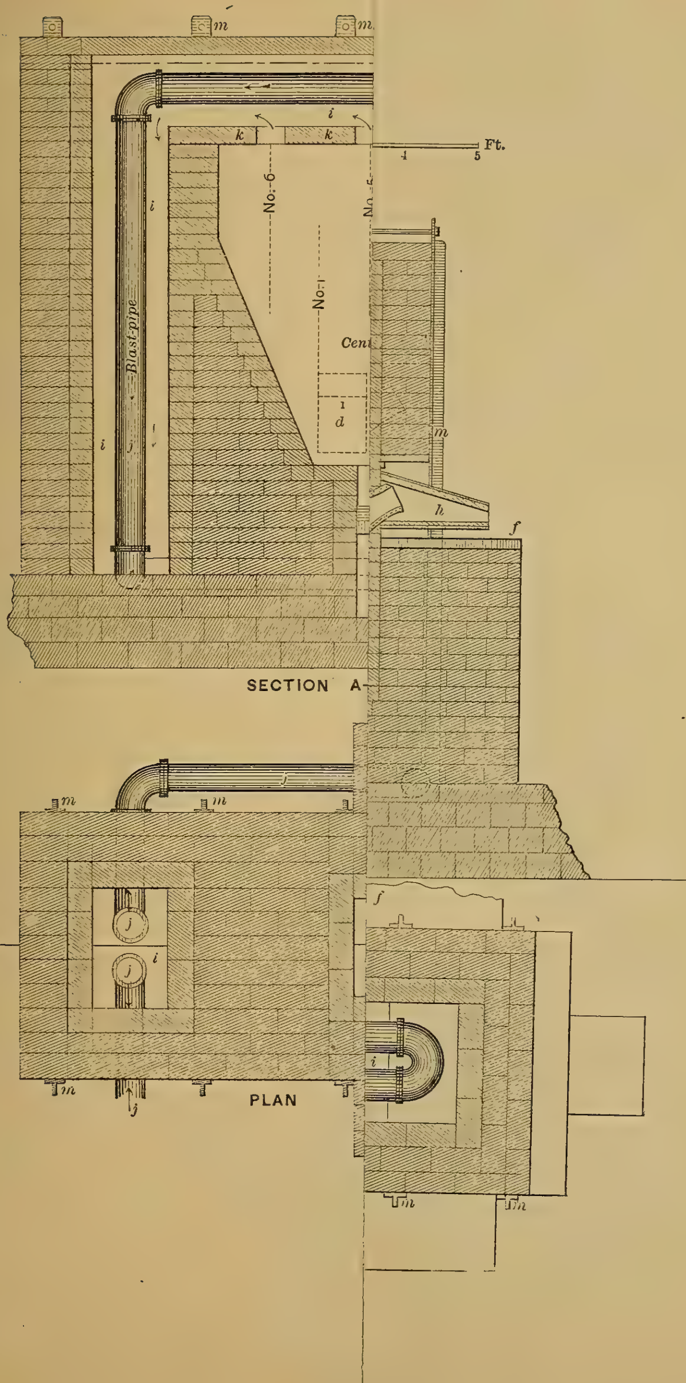

m
m
Ft.
4
5
k
k
i
No. 6
No. 5
No. 1
Blast-pipe
Cent
d
m
h
f
i
j
SECTION A
m
m
f
j
j
i
i
PLAN
m
j
m
m

Fig.8.
BRODIE'S DISTILLATION FURNACE.

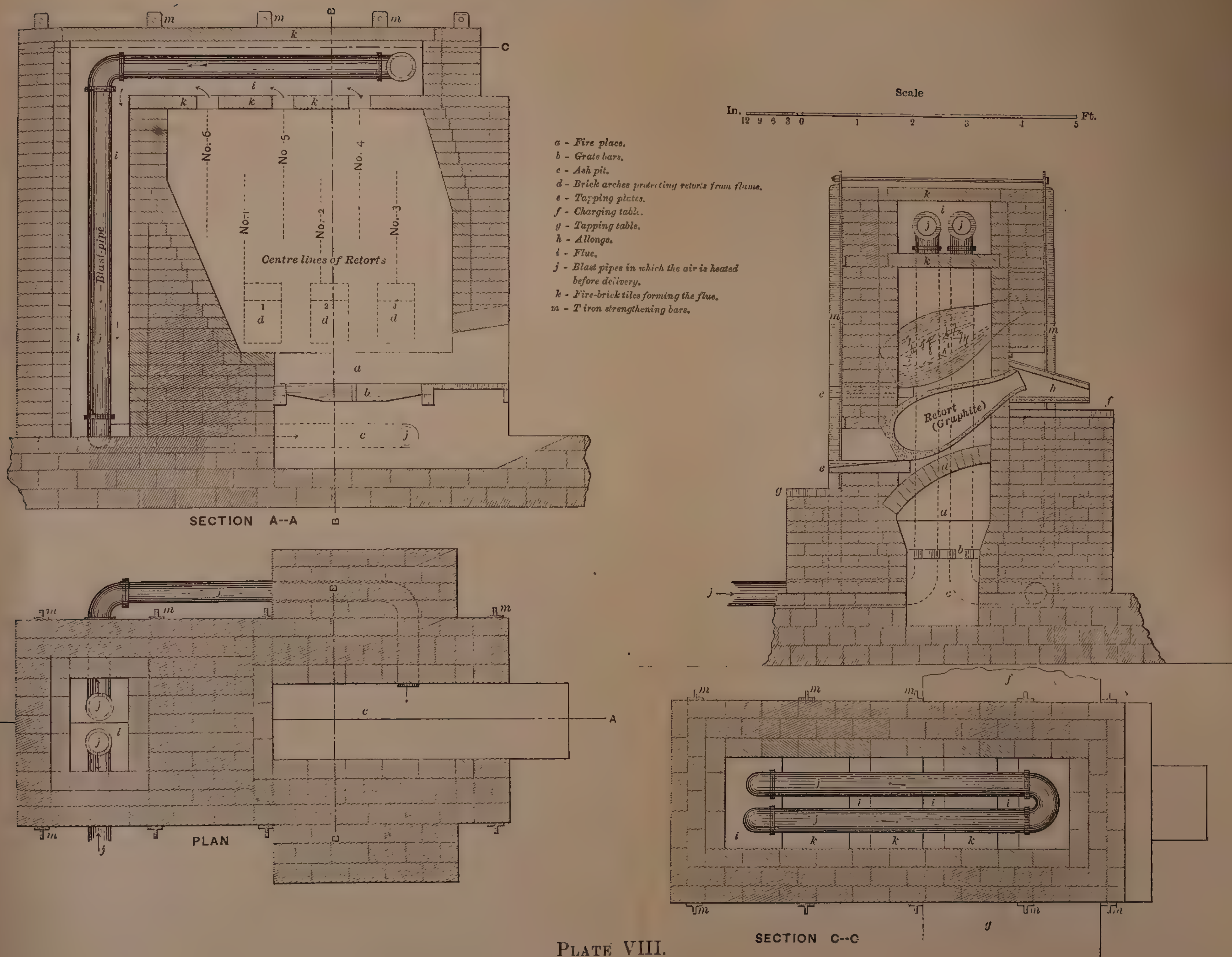
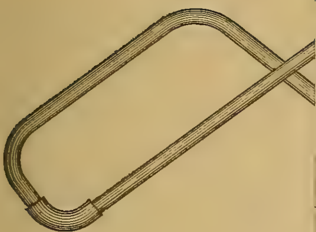


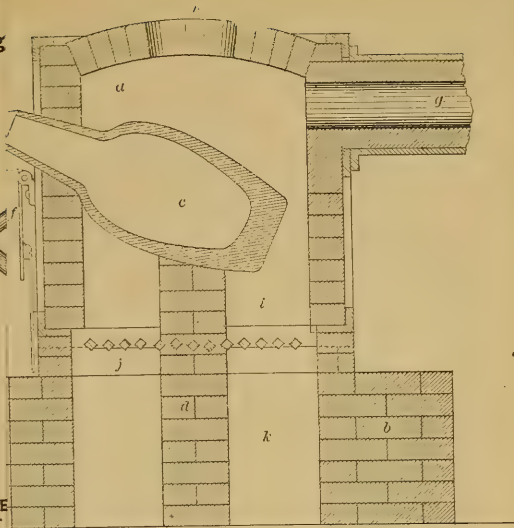
PLATE VIII.

Fig



STEITZ'S SIPHON TAP FOR THE

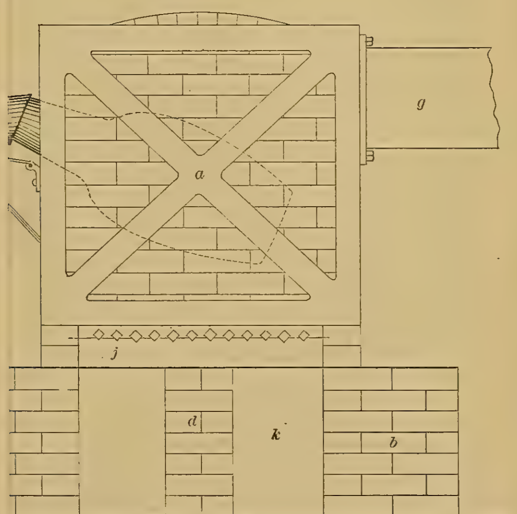
In. 12 9 6 3 0



SECTION B–B

supporting Allonge
lined with fire brick

for grate bars

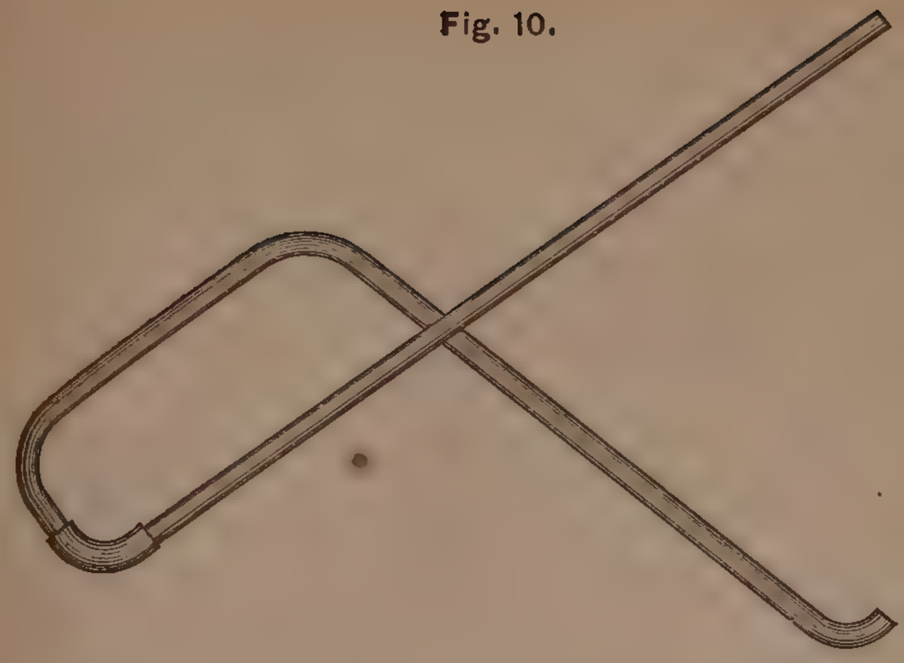


SIDE ELEVATION

Scale 2 3 4 Ft.

PLATE IX.

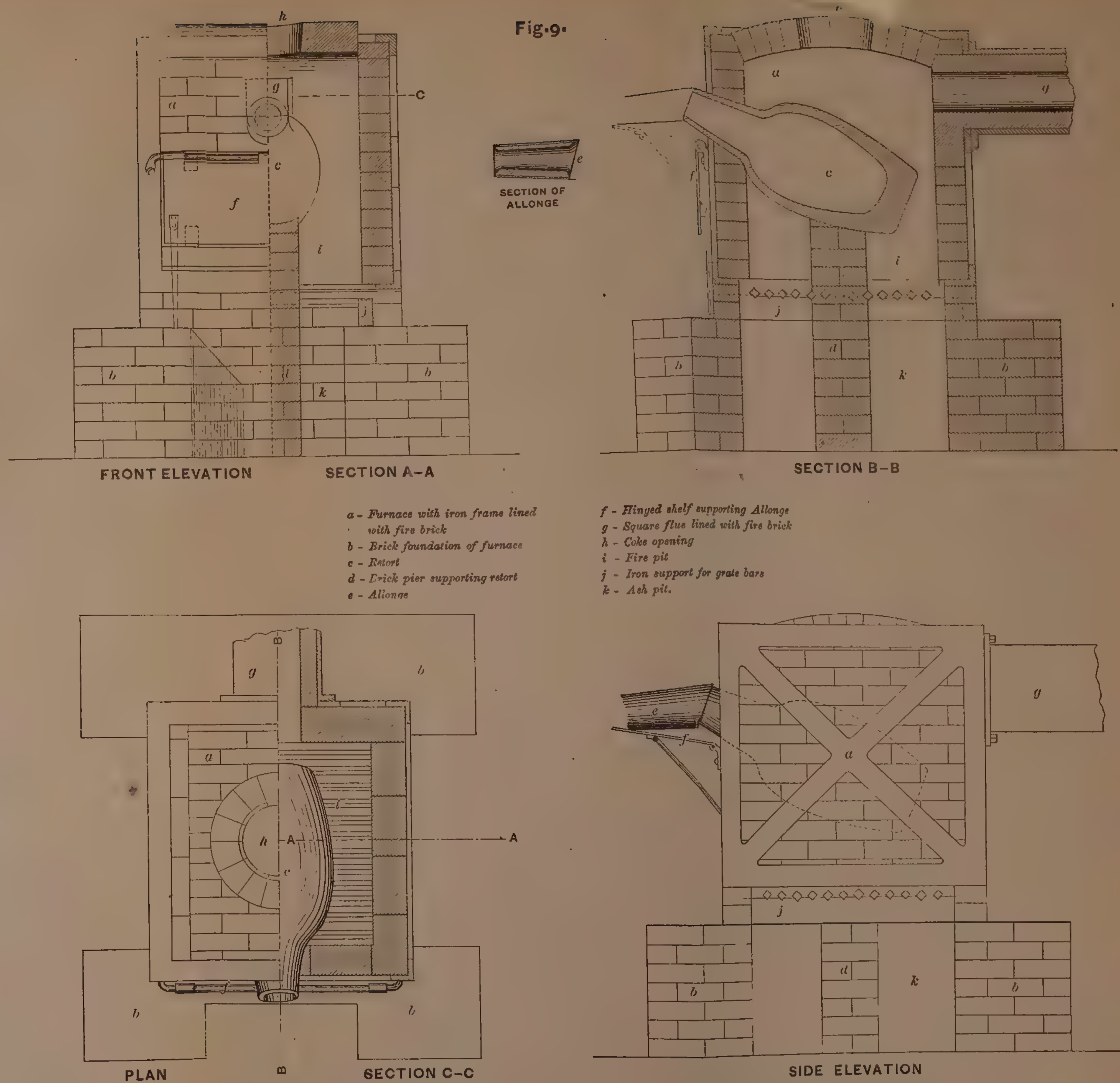
Fig. 10.



STEITZ'S SIPHON TAP FOR THE DISTILLATION FURNACE

Scale In. 12 9 6 3 0 1 2 Ft.

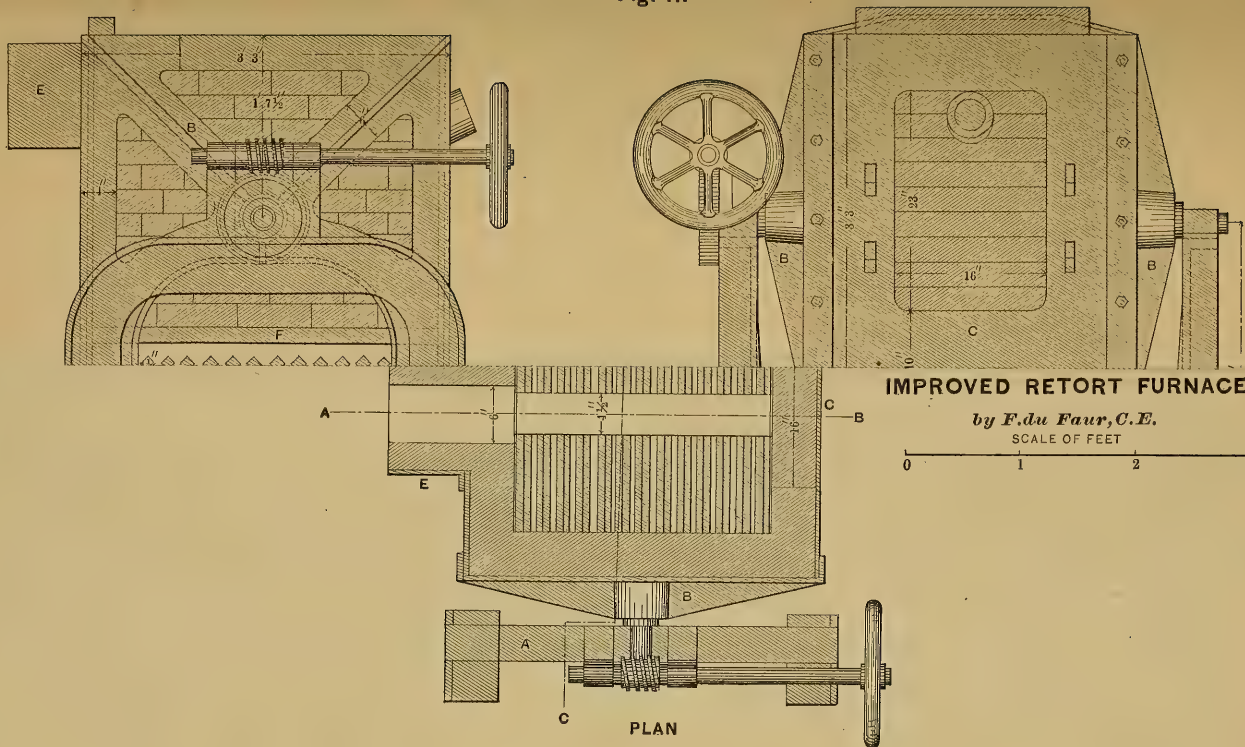
Fig. 9.



a - *Furnace with iron frame lined with fire brick*
b - *Brick foundation of furnace*
c - *Retort*
d - *Brick pier supporting retort*
e - *Allonge*
f - *Hinged shelf supporting Allonge*
g - *Square flue lined with fire brick*
h - *Coke opening*
i - *Fire pit*
j - *Iron support for grate bars*
k - *Ash pit.*

In. 12 9 6 3 0 1 Scale 2 3 4 Ft.

PLATE IX.



IMPROVED RETORT FURNACE

by F. du Faur, C.E.

SCALE OF FEET

0 1 2 3

PLATE X.

Fig. 11.

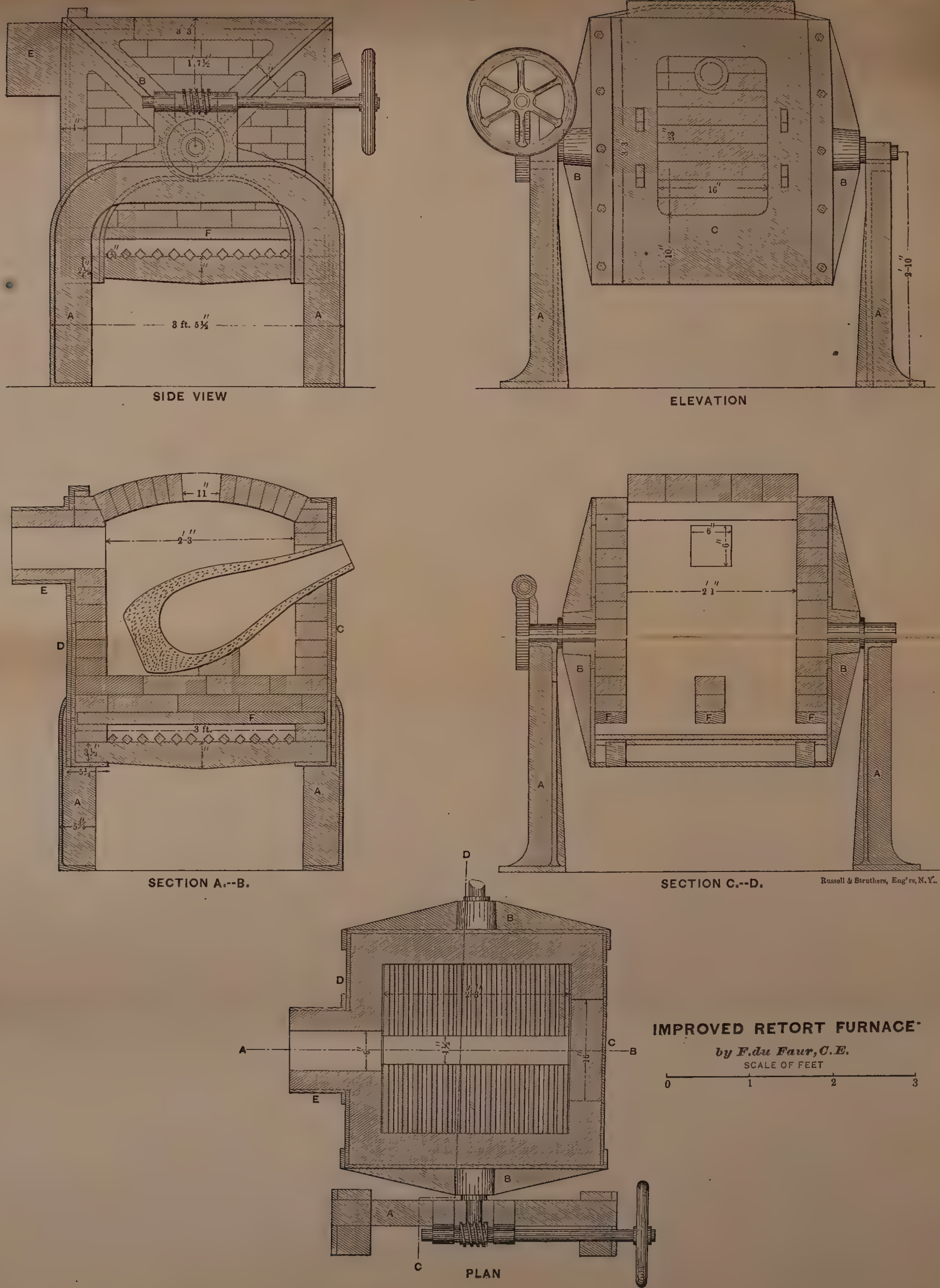
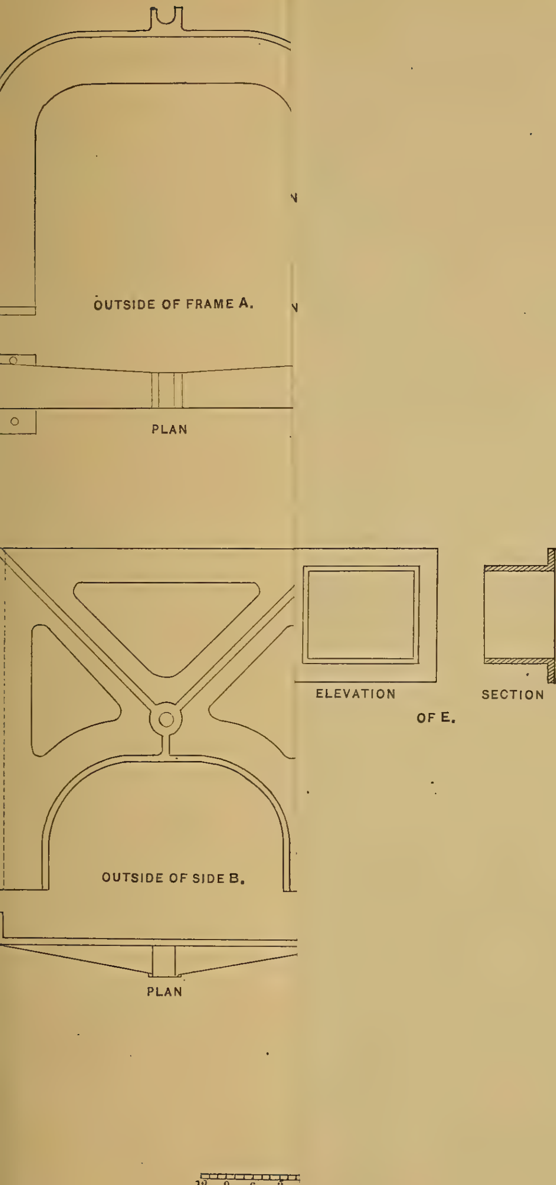
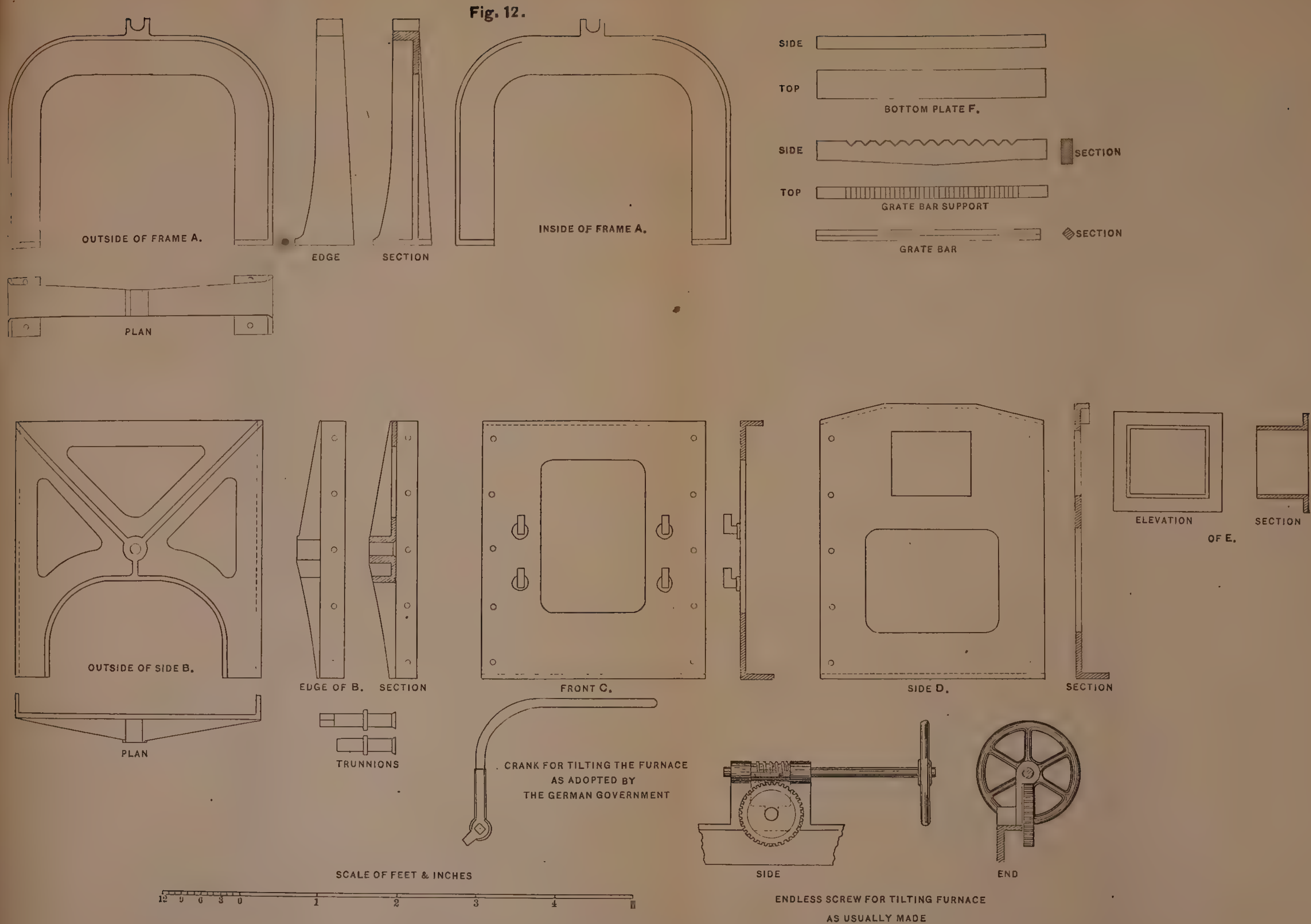


Plate X.

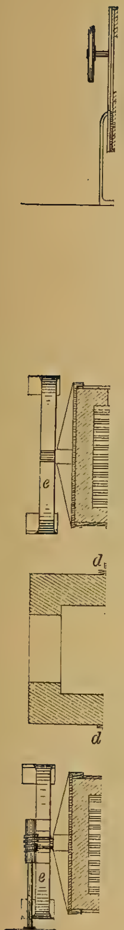

OUTSIDE OF FRAME A.
PLAN
ELEVATION
SECTION
OF E.
OUTSIDE OF SIDE B.
PLAN
12 9 6 3

S, ENG'S, N.Y.



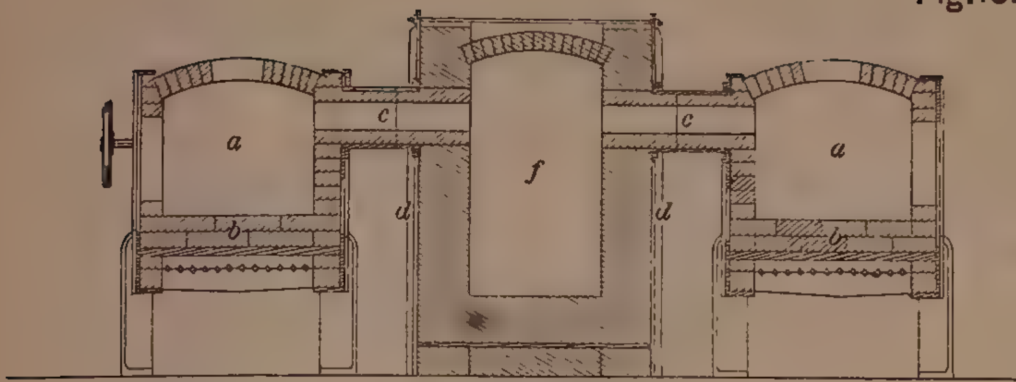
DETAILS OF A. FABER DU FAUR'S RETORT FURNACE.

PLATE XI.



PL/

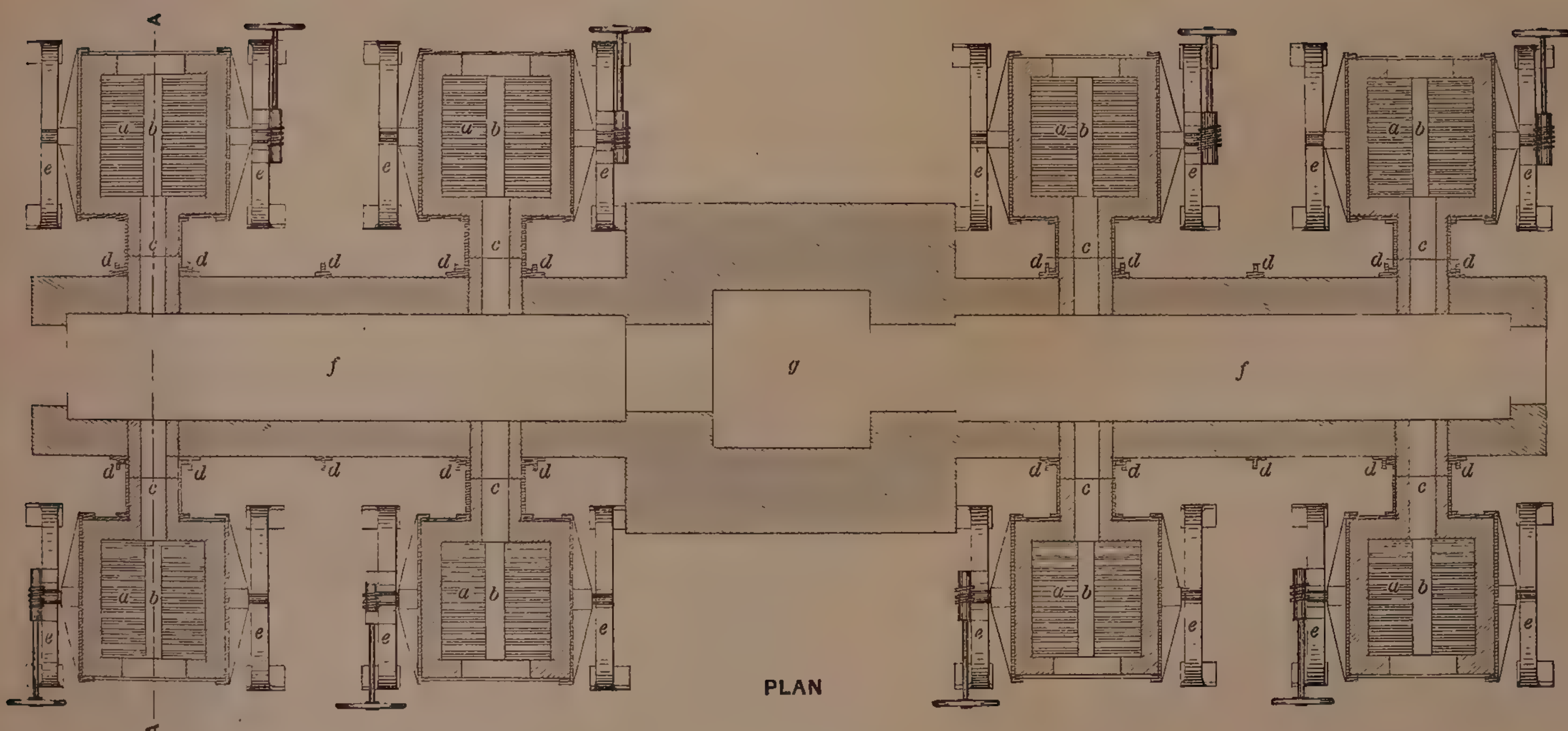
Fig.13.



SECTION A--A

a - Faber Du Faur's tilting furnace.
b - Support for retort.
c - Flue jointed so that the furnace may swing.
d - Vertical T iron ties holding brick walls together.
e - Stands supporting furnaces
f - Main flue.
g - Chimney 60 feet high.

Scale In. 12 6 0 1 2 3 4 5 6 7 8 9 10 Ft.



PLAN

Brick *Fire brick* *Iron in section* *Iron in elevation*

PLAN OF FABER DU FAUR'S TILTING RETORT FURNACE AT THE GERMANIA WORKS FLACH'S STATION, NEAR SALT LAKE, UTAH.

PLATE XII.

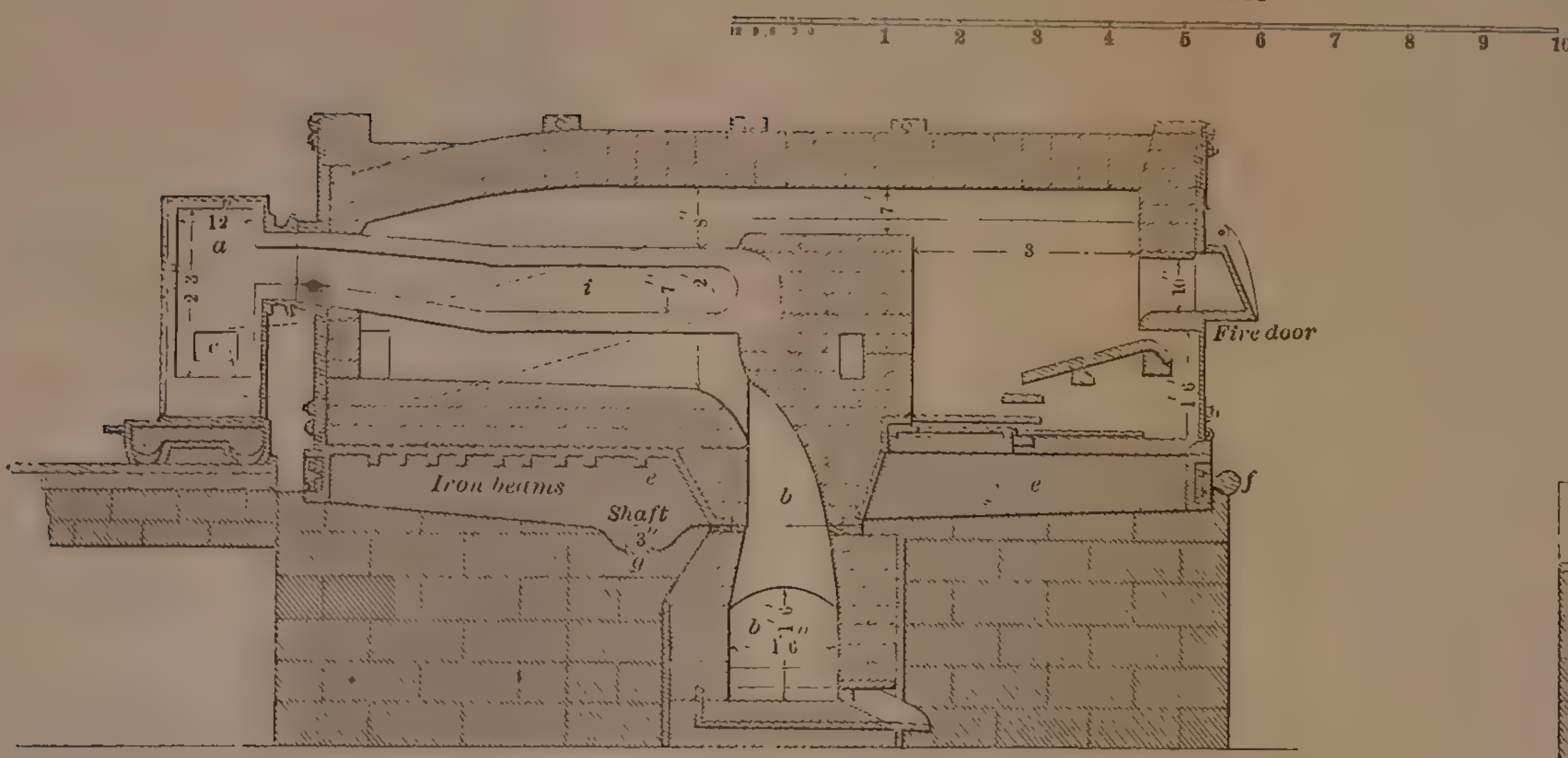
A —

Fig. 14.

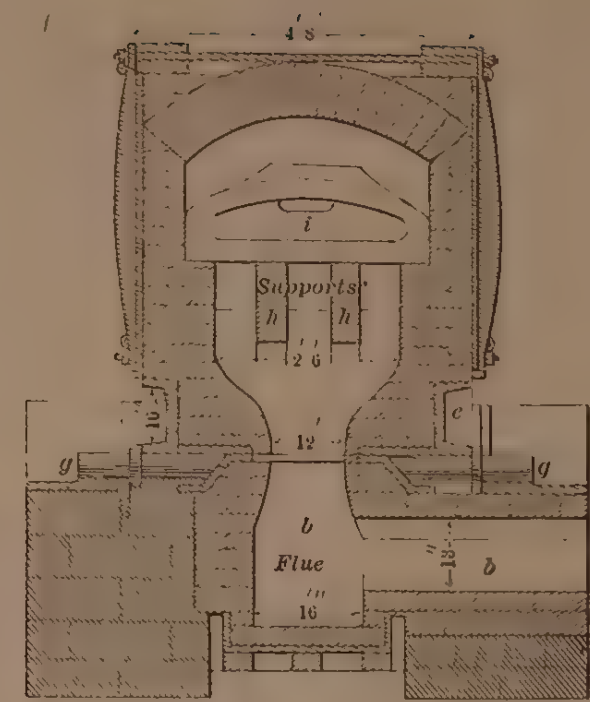
TILTING FURNACE

FOR FLAME OR GAS; BY F. DU FAUR.

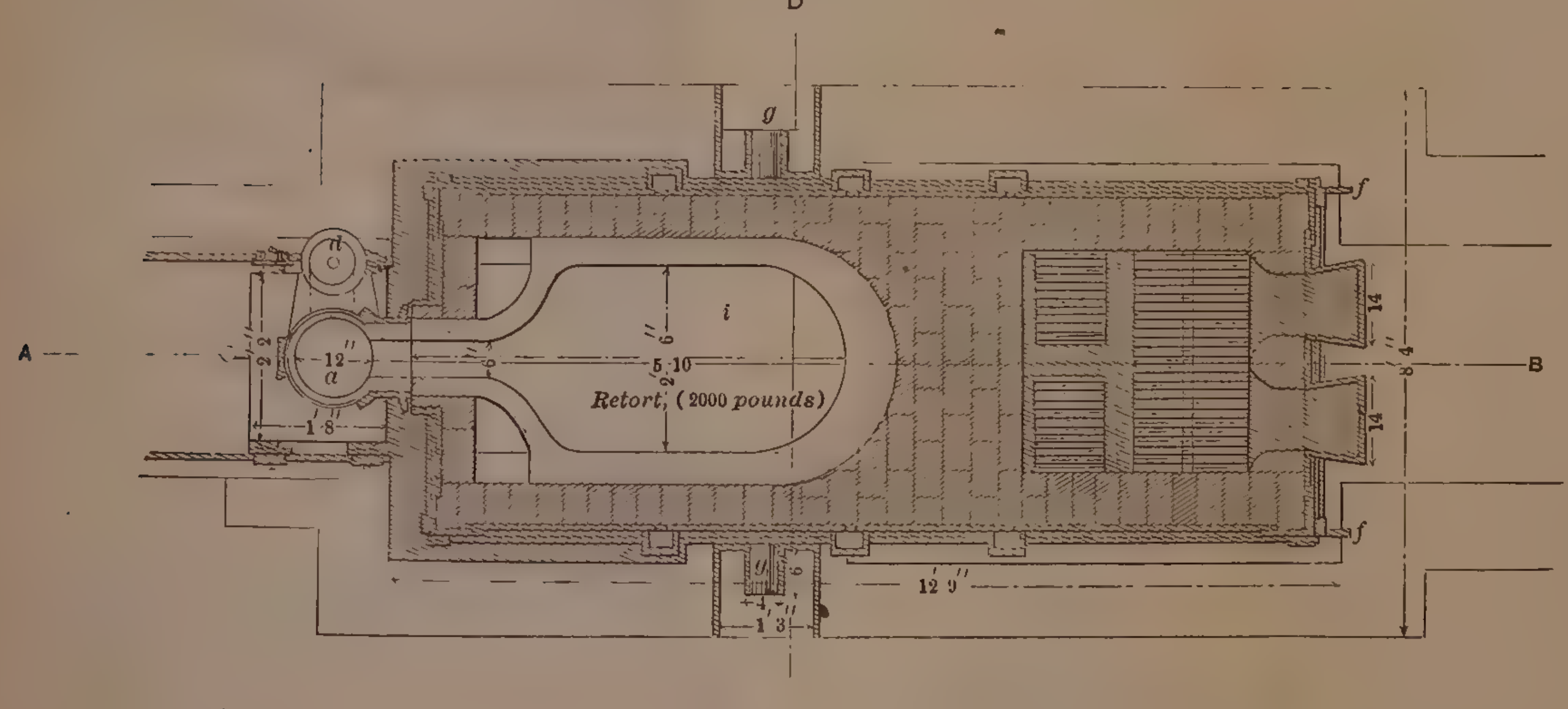
SCALE OF FEET AND INCHES



SECTION THROUGH A.B.



SECTION THROUGH C.D.



a - Condenser on truck.
b - Underground flue.
c - Gas-escape.
d - Gas-escape-flue with a movable cover for cleaning condenser.
e - Iron beams on which the furnace is built tilted at *f*.
g - Trunnions on which the furnace moves.
h - Fire-brick supports for the retort *i*.
i - Retort.

PLATE XIII.

ANNALS

OF THE

NEW YORK ACADEMY OF SCIENCES.

VOLUME 2, 1880—82.

The "Annals," published for over half a century by the late Lyceum of Natural History, are continued under the above name by the NEW YORK ACADEMY OF SCIENCES, beginning with the year 1877.

It is proposed, as before, to issue four numbers every year, each number to consist of not less than thirty-two pages (octavo), with or without plates. Price of Yearly Subscrption, Two Dollars, payable in advance.

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LATE

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IX.—*On Helix aspersa in California, and the Geographical Distribution of certain West American Land-Snails, and previous errors relating thereto, &c.*

BY ROBERT E. C. STEARNS.

UNIVERSITY OF CALIFORNIA.

Read March 28th. 1881.

The presence of the well-known European land-snail, *Helix aspersa,* in California, as an inhabitant of the State, is verified by living specimens received by me recently, through the kindness of Mr. Harford, of the California Academy of Sciences. They were collected near San José, in Santa Clara County, where it is stated that a colony exists, which, as will be seen by the foot-note,* was planted *twenty-three years ago!*

---

* In a reply to Mr. Harford's inquiry, Mrs. A. E. Bush, of San José, writes,—"I learn that *H. aspersa* was brought from France to San José about twenty-three years ago, by Mr. A. Delmas, and turned out on the Guadalupe, probably with the grape-vines. You have evidence that the first colony of Helices are doing well. I do not learn that any one else has ever brought any. A son of Mr. Delmas gave me the information, and also, that they were planted in the southern part of the State at the same time, where they were put on the grape-vines, and that they have done better there than here. * * * * * They were probably brought here as an experiment, and have been eaten, and have not spread beyond the locality where first planted. There are a few French families about there [*i. e.* on the Guadalupe], but they seem very unwilling to give any information, which may be, because Americans are prejudiced against snails as an article of food. * * * Am satisfied that the handful * * * that I got were intended for the pot * * * .

The soil where the colony was placed is a rich, sandy loam, well shaded; when the summer heats come, the Helices descend into the ground several feet, in the cracks that form as the ground dries; and the gopher-holes make retreats also for the Helix."

It should be borne in mind that the San José referred to herein, is an interior town or city of many thousand inhabitants, several miles back from

At first thought, one is led to doubt the probability that such a form, in a locality near to any considerable population, could be so long unknown to naturalists; but when we consider the facts, *first*, that the place where it was planted was on private ground of considerable area, several acres; *second*, that the climate of the region, with its long rainless summers, is not so conducive to the rapid multiplication of individuals as is the native climate of the species; *third*, that the increase was quite likely the measure of consumption as food by the parties owning the locality; and, *fourth*, that the presence of the species was kept secret by those who used it,—the improbability is greatly reduced.

The detection of individuals of this species in this part of the world recalled the fact of its having been previously reported from this coast, over *thirty years ago*; yet, during all this time, not the first iota of confirmatory testimony has been obtained, and the credit at that time to our faunal list has ever been regarded, by our local naturalists and collectors, as without valid foundation.

I have been curious to look into the matter, and to seek for the source of this error, for error it undoubtedly is.

In pursuance of this inquiry, I find many other west coast species incidentally involved, and many errors in habitat, which have been so often repeated, as to justify the time required for their correction, if accuracy of statement as to geographical distribution is of any importance.

Mr. W. G. Binney, in his recent volume* on "The Terres-

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the coast, and distant between two and three hours' ride by rail from San Francisco, southward.

The "Guadalupe" referred to, is a river formed by several minor streams; it flows northerly through Santa Clara Valley, and empties into the Bay of San Francisco at its southerly end, near Alviso; the valley is comparatively thickly settled, the region being one of the most fertile in the State. The "Guadalupe" river, as above, must not be confounded with "Guadalupe island," mentioned later in this paper.

The colony planted in the southern part of the State, as reported by Mrs. Bush, has not as yet been discovered; the climate, etc., is much less favorable for its perpetuity than that of the Santa Clara Valley.

* Volume V, July, 1878. See, also, Binney (Senior), in Vol. II, p. 117.

trial and Air-Breathing Mollusks of North America, etc.," reports this species, as found "In gardens in Charleston, South Carolina, and vicinity, where it has existed for fifty years: I found it plentifully in St. Michael's Churchyard, in 1875; also, has been found at New Orleans and Baton Rouge; Portland, Maine; Nova Scotia; Santa Barbara, California; Hayti, St. Jago, Chili, etc.; it is a European species, accidentally introduced into this country, or rather by commerce as an article of food. It evidently is a species peculiarly adapted to colonization."

Though credited to California as above, I have always thought that this was an error arising from hasty or mistaken determination, and that the shell upon which it rests was either an individual of the species since described as *H. Tryoni** or *H. Stearnsiana*,† or perhaps an aberrant *H. Kellettii*, of which specimens sometimes occur, which in color, elevation and general aspect, resemble dwarf individuals of *H. aspersa* of Müller. My previous quotation from Mr. Binney will show that the latter species is credited to *Santa Barbara*; it has never been confirmed from said point, or from any other on the west coast of North America, by any of the numerous collectors of later years. Dr. Cooper, in his Geographical Catalogue of the Mollusca (April, 1867), very properly omits it from the list of West American species. I have numerous specimens, however, of *H. Tryoni*, from Santa Barbara Island.

The late Dr. Philip Carpenter, in his Report on the Mollusca of the west coast of North America,‡ says, "Among the wasted opportunities of obtaining very valuable information on geographical distribution, must unfortunately be recorded the surveying voyages of the 'Herald' and 'Pandora,' Capt. Kellett, R. N., C. B., and Lieut. Wood, R. N. The former of these gentlemen commanded the 'Starling' during the Sulphur Expedition. Their zeal for science is shown not only by the large number of fine and valuable shells which they brought back, but

---

* Described by Dr. Newcomb, in 1864, and

† By the late Dr. Gabb, in 1867.

‡ To the British Association, 1856, paragraph 50.

especially by the extreme liberality with which they have presented them to public museums wherever they thought they could be made useful. The shells were deposited in the Museum of Practical Geology in Jermyn Street, London, then presided over by Prof. E. Forbes. He writes that 'they were chiefly collected on the coast of Southern California, from San Diego to Magdalena, and the shores of Mazatlan.'" Carpenter continues, saying, "this is precisely the very district of all others on which we are in want of accurate information. San Diego belongs mainly to the Californian province, Mazatlan to that of Panama; the question yet to be settled is, where and how do they separate? Here was an exploration in competent hands, on the very *terra incognita* itself; and yet, alas! Prof. E. Forbes further states, that "unfortunately the precise locality of many of the individual specimens had not been noticed at the time; and a quantity of Polynesian shells mingled with them, have tended to render the value of the collection, as illustrative of d'stribution, less exact than it might have been." Such information as was accessible at the time was embodied by Prof. E. Forbes, in two communications to the Zoological Society, 1850; the first on the Land Shells, collected during the Expedition. *Proc.*, pp. 53—56; the second on the Marine Mollusca, pp. 270—274." * * *

It would expand this paper unduly to quote the entire paragraph, so I will only add the following, from the same author, from the same and following pages:

"*Helix Pandoræ,* Forbes, p. 55, pl. 9, f. 3; *a, b.* Sta. Barbara, as per box-label: San Juan del Fuaco, teste Forbes. —*Kellettii,* Fbs. p. 55, pl. 9, f. 2; *a, b.* Allied to *H. Californiensis,* Lea. Same locality. * * * * * * * * * * * —*aspersa,* marked Sta. Barbara; probably imported, p. 53."

Then follows a list of the marine forms described by Prof. Forbes, succeeded by Carpenter's remarks: "The types of the described species, and numerous most beautiful and interesting specimens, have been presented to the British Museum. The remainder may be seen by students in the drawers of the Mus. Pract. Geol.; but the condition of the labels is not such that any dependence can be placed on them, unless confirmed from other sources. * * *

"So large a number, even of those placed with the Mazatlan

shells, and perhaps obtained by commerce from that spot, are known to be inhabitants of the Pacific Islands and the East Indies, that a list of them would be entirely useless for our present object."

The closing lines of Dr. Carpenter hardly justify the previous remark, "an exploration in competent hands," etc.; and a recurrence to the species cited shows, that even so eminent an authority as Prof. Forbes was, to use a common expression, "at sea," in the matter of locality;* while the box-labels were more nearly, if not quite right. Mr. Binney† gives the habitat of *Kellettii* as "San Diego; Catalina Island, San Nicolas Island, California;" and Cooper‡ refers it to "Catalina Island, San Diego and south." The latter author does not refer to *H. Pandoræ,* as it is not an inhabitant of the Californian and Vancouver zoölogical province, being south of the southern limit of his catalogue, which covers the region "between latitudes 33° and 49° north."

Binney, in the volume quoted, properly credits *H. Pandoræ* to "Margarita Bay, Lower California." Forbes's habitat of this species is only *seventeen hundred* miles too far north,—and of *Kellettii, eleven hundred.*

Another distinguished author‖ has placed the Lower Californian *Helix levis* on the Columbia river,—about *fifteen hundred miles* too near the north pole.

Tryon§ properly credits it to Southern California,¶ and adds in a note that our mutual friend, Dr. Newcomb, sent him speci-

---

* Forbes's "San Juan del Fuaco," perhaps should have been *San Juanico,* a small port in Lower California on the outer coast, lat. 26° N., and within the territory inhabited by *Pandoræ, areolata,* etc. For the sake of brevity, it is often called "San Juan."

† Vol. V.

‡ Geog. Catalogue, etc.

‖ Mon. Hel. Viv., I, 154; III, 128; Zeitschr. f. Mal., 1845, 152; in *Chemnitz,* ed. 2, I, 249, pl. XXXVI, f. 16, 17 (1846)—Reeve, Con. Icon., 1214;—and other authors cited by Binney in L. & F. W. Shells of N. A., Part I, p. 180.

§ Am. Jour. Conch., Vol. II, p. 320.

¶ Meaning Lower California.

mens of it "from Bay of Monterey, Cal., as a variety of *H. areolata*," which latter he refers* to "Oregon, California." This was undoubtedly a *lapsus calami*, on the part of the Doctor. The geography is slightly obscure, and neither of the stations are correct; also *H. intercisa*, W. G. B., an insular species found on the islands off the coast of the southern portion of California proper, is credited by him to "Oregon," in pursuance of Binney's error, which the latter author has indicated in his recent volume.†

Mr. Hemphill wrote to me (in July, 1879) just after his return from the region, "I have *Helix intercisa*, Binn., and its vars., also small dark and light vars. of *H. Kellettii* from San Clemente Island." Catalina Island is apparently the metropolis of the latter form.

San Miguel, Santa Rosa, Santa Cruz and Anacapa, are islands in what is called the Santa Barbara Channel; while Santa Barbara, Santa Catalina, San Nicolas and San Clemente, are further south; of these, Santa Rosa, Santa Cruz, and Santa Catalina, are the principal or largest, while San Miguel, San Nicolas, and San Clemente, are farthest from the main land.

As regards *H. Kellettii*, Kellett and Wood may have found it on Santa Barbara Island, or on some of the islands in the Santa Barbara Channel, and marked the box "Sta Barbara," without intending to mean the place or town of that name on the main land; but as *Kellettii* has not been reported by later and more accurate collectors from Santa Barbara Island, it is far more likely that a variety of *Tryoni* is really the shell referred to as "*aspersa*."

As to *H. aspersa*, it would be quite absurd even to imply that so excellent a naturalist as Mr. Forbes was not intimately acquainted with every aspect and variety of a form so abundant as this, both in England and on the Continent.

As before stated, its occurrence as above has never been verified; and though a species of cosmopolitan plasticity, in its ready adaptation to new regions, there was no commercial intercourse

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* Am. Jour. Conch., Vol. II, p. 319.

† Vol. V, p. 361.

between any of the places where it had previously been found and that part of California to which Prof. Forbes credits it, up to the date of said credit, or, rather, the date of the "Herald" collection. Since then, during the time which embraces the "great emigration" following the discovery of gold in California in 1849, that part of the coast of California has had but little if any direct contact with vessels from ports in countries where *H. aspersa* exists. Prior to 1849, the coastwise traffic was very insignificant, and the foreign commerce consisted only of the few vessels engaged in the hide and tallow trade, and the whalers; therefore its introduction by such means is altogether improbable.

For the very reason that Forbes was intimately familiar with *aspersa* in all its varied aspects,—I believe he was led to credit it to the West coast through the striking resemblance which occasional specimens of *Tryoni*, *Stearnsiana*, and *Kellettii* bear to occasional specimens of *aspersa;* not typical or average specimens, but extreme, unusual, but occasional individuals.

I have before me now a specimen which connects extremes of *Kellettii* and *Stearnsiana;* it is strikingly like an extreme specimen of *aspersa* which is also before me. I have likewise, specimens of rather dark colored *H. Tryoni*, which strikingly resemble a light colored dwarf *aspersa*.

If the California specimens referred to in this comparison were placed within a region where *aspersa* is abundant, they would at once be regarded as dwarf varieties or aberrant individuals of that species. If the specimen of *aspersa* referred to was placed within the territory of either *Tryoni*, *Kellettii*, or *Stearnsiana*, it would be considered a variety of one or the other according to the area within which it was placed.

Having possessed, seen, and noticed at various times a great number of all of the species above named, and observed their range of variation and approximation to other forms, I regard this hypothesis, as to Forbes's *H. aspersa* in "Sta Barbara," in connection with the other related points presented, as a reasonably satisfactory solution of the matter; as furnishing a better basis for Forbes's credit of *aspersa* to this coast, at that time, than any other that is left us to choose from, viz., that the shell he had before him was a veritable *aspersa*;—or that a true *as-*

persa got mixed in with the *"Herald"* shells after the latter arrived in England. Though the above hypothesis does not exonerate the collectors of the "Herald" shells from the carelessness evident in their labels, it does favor them with an explanation which places their habitat (as per label) within a comparatively near proximity to the proper specific areas, which our present knowledge indicates as correct.

It is, however, really extraordinary that any author who had seen the actual shells of the above American species and possessing any knowledge of the relation of climate to coloration, should have placed any of them without great hesitation and careful research at so northern a station as this inquiry and a reference to their works reveals. Take all the West American species named in this paper, and their external aspect points conspicuously to a habitat of minimum rainfall or moisture; and the aspect of the species, taken together as a whole, points to a region of aridity, or where aridity is the rule and not the exception.

The time will come, and it is not creditable to the management of museums anywhere, that it has not already arrived, when collections will be arranged in double order, or under two systems; one, and the *least* important—now made the *most* so—that of a classified arrangement according to the best authorities; the other, a geographical arrangement,—carefully placed—according to the geographical distribution of animal life. Aside from the light which such an arrangement would throw upon many other points of great importance,—in the matter of climatology a better knowledge of a great region would be presented at a glance than by all human records, or since civilization reached the point of meteorological observation.*

The various forms included under the names of *H. areolata*, *Pandoræ*, *Veatchii* and *levis*, I regard as varieties of a single species. The first two are found in great numbers on the shores and in the region about Margarita† or properly Magdalena bay,

---

* In connection more or less directly with this line of investigation, see Cooper "On the Law of Variation, etc.; California Land Shells; Cal. Acad. Proc., 1873, p. 121 and elsewhere.

† Margarita is a large island, whose shores form a part of the boundary of Magdalena bay; hence the bay is sometimes so named by writers and sailors.

Lower California. Mr. Fisher found Helix *areolata* abundant on the shores of Santa Maria bay, which is a small bay indenting an island of that name, outside of Magdalena bay. *H. Veatchii* and *H. levis* are insular forms, usually much more globose and elevated than their relatives from the main land. *H. Veatchii*, the largest of the four, is from the large island known as "Cedros" or "Cerros;" which forms the greater part of the western boundary of the bay of St. Sebastian Viscanio, lat. 28° to 29° N. Fisher found *levis* abundant dead in Asuncion, a small island south of Cedros, in lat. 27°. Magdalena bay is still further south, more than half way between Cedros Island and Cape St. Lucas.

The tubercle on the columella is sometimes present and sometimes absent in all the above; it has no value, in this group at least, as a specific character; this conclusion I have reached after the examination of hundreds of individuals of all these so-called species.

Binney regards *Veatchii* as a synonym of *areolata*, but he recognizes *Pandoræ* and *levis* as valid species. Neither of the four figures* he gives of *H. areolata* are characteristic of the main-land forms,—being too elevated, though they may be typical in pursuance of the original description; the two larger figures are good for *Veatchii*, the two smaller for *levis*. *Veatchii* is full as much entitled to specific rank as either of the others.

Mr. Tryon recognizes all as valid species; he places *areolata*, *Pandoræ* and *levis*, in the subgeneric group POLYMITA, and *Veatchii* in ARIONTA. Binney puts them together in EUPARYPHA.

I cannot but regard these subgeneric divisions, to a great extent, as arbitrary and unsatisfactory; they seem to be more or less fanciful and superficial, and based upon too narrow and unsubstantial grounds; and the frequent differences of opinion on this point by such conscientious authors as those whom I have quoted, confirm observations made in the cabinet and the field.

As a matter of information not unrelated to the general subject of this paper, I may mention the detection of fossil speci-

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* Land and F. W. Shells of N. A., p. 177, fig. 311.

mens of *H. Tryoni* Newc., in Santa Barbara Is., *H. tenuistriata*. Binney,—from the same locality; *H. intercisa*, W. G. B., from the shell-heaps of San Clemente Is., and *H. Stearnsiana*, Gabb, fossil, from about four miles above the mouth of San Tomas river, Lower California, collected and presented to my museum by Henry Hemphill, Esq.

The comments of Mr. Binney* relating to a specimen of *H. tenuistriata* (so-called) from Catalina Island, impress me as applying to the specimens so-named from Santa Barbara Is., as above. They appear to be forms of *H. Gabbi*, Newc. Again, Mr. Binney's opinion as to the identity of *Gabbi* and *facta*, in the same page of the same volume, I regard as correct. He might also have included *H. ruficincta*, or *rufocincta* as Dr. Newcomb named it.

Binney places these three species (all of Dr. Newcomb) in the group ARIONTA; Tryon in AGLAJA. Binney, referring to the soft parts of *Gabbi* and *facta*, says:—"Genitalia, * * * without the accessory duct of the genital bladder, and with a dart-sac. They resemble nearly those of *ruficincta*, * * * differing chiefly in the length of the duct of the genital bladder." The number of whorls is the same in all three, namely, 5 to 6; the general aspect is the same, presenting no other essential difference than size. *H. facta* is "also found, the variety with the open umbilicus, like that form found fossil on San Nicolas Island, California,"† on the Island of Guadalupe, which is about 220 miles from San Diego, off the west coast of Lower California.

Before closing, I will notice, as worthy of inquiry, the apparent relation between the *saline*, sandy, wind-swept stations inhabited by *Helix Ayresiana*‡ (*not Ayersiana*) and *Helix intercisa*, and the sharp obliquely-reticulated sculpture which characterizes these species.

The first of these was credited to "Oregon," in Dr. Newcomb's original description, instead of the islands of Santa Cruz,

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* L. & F. W. Moll., Vol. V, 1878, p. 372.

† Binney, Proc. Phil. Acad., 1879, p. 16.

‡ Named for Dr. W. O. Ayres, *not Ayers*.

San Miguel, and Santa Rosa, where it has since been found, by Harford, Hemphill, and others. It is nearly related to *H. Dupetithouarsii*, which occupies a maritime, but less exposed wooded station on the main land, much farther to the north, near Monterey bay, in Monterey County; south of said county is a long stretch, a large area extending southerly to Point Conception at the head of the Santa Barbara channel, which embraces the counties of San Luis Obispo and Santa Barbara, where *H. Traskii*, another closely related form, occurs; south of the point is the small island of San Miguel and the larger ones of Santa Cruz and Santa Rosa, where *Ayresiana* is found. *H. Ayresiana* is much lighter colored than the average of *Dupetithouarsii*; it inhabits a more arid and treeless station; its general tone may be described as a dingy light *café-au-lait*, with a rather broad reddish-brown band, which in some individuals is obscure or entirely obsolete. *H. Traskii* sometimes exhibits the sculpture herein noticed. Specimens of *H. intercisa* from San Clemente island are sometimes beautifully sculptured.

Of the San Clemente snails, for which I am indebted to the courtesy and generosity of Mr. Hemphill, *H. intercisa*,—with which Mr. Binney includes *H. crebristriata*, Newcomb, as a synonym,—is closely related to *H. Tryoni*,* and the *H. redimita* specimens, received from the same gentleman, indicate an equally close connection with *H. Kellettii*, which has the same number of whorls, and other characters in common.

It will be observed, upon a comparison of the shells herein recited, and the stations wherein they are found, that the geographical proximity or relationship also corroborates the views herein expressed.

Further testimony, showing the propriety of my remarks as to subgeneric divisions, is presented by reviewing the relationship of these San Clemente snails, and comparing the same with the positions heretofore assigned to them.

February, 1881.

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* I find Mr. Binney practically agrees with the above, upon turning to Bull. Mus. Comp. Zool., Vol. V, p. 357, which see.

X.—*The Life-History of Spirifer lævis, Hall:—a Palæontological Study.*

BY HENRY S. WILLIAMS.

Read April 25th, 1881.

In middle and western New York, cropping out also in some localities westward and southward, appears a series of shales and shaly sandstones known as the Portage group.

The total thickness of the series, as defined by Hall, is from 1000 to 1400 feet in the western part of New York State. Leslie defines 1450 feet of Portage Flags in Pennsylvania.

The "Erie shales" of Newberry are considered as the same rocks in Ohio, where they thin out and disappear west of the Vermilion River.

Rocks corresponding to the upper layers of the Hamilton Period, or lower part of the Portage, are found further west, and are called "Black slates," or "Black shales,"—the "Huron" in Ohio, and the "Huron group," Winchell, in Michigan.

Although the line between the Hamilton and Chemung Periods is not clearly defined in these western outcrops, these "black shales" and "Huron" slates are apparently more closely connected historically with the Hamilton Period than with the Chemung; and we may regard the true Portage shaly sandstone, in which the characteristic fossils occur in western New York, as limited in outcrop to middle and western New York, Ohio and Pennsylvania.

In the upper part of the Portage beds, in a few localities only, has been found a large, smooth-surfaced, unplicated fossil of the genus *Spirifer*, described first by Hall, in the Geological Report of the Fourth District of New York, 1843, p. 345, fig. 1, under the name of *Delthyris lævis*. This was afterwards (1867) more fully described and carefully figured in the fourth volume of the Palæontology of New York as *Spirifera lævis* (l. c., p. 239, pl. XXXIX) by James Hall. In the latter description, two

localities are given—near Ithaca, Tompkins Co., and near Cortlandville, Cortland Co.

The species is also recorded from the shores of Seneca Lake; also, there are specimens in the Museum of Cornell University labelled from Flint Creek, Ontario Co. There is, however, reasonable doubt as to the correctness of the label. Only a few localities are known in which this large fossil is found, and, so far as I can learn, none outside of the State.

A study of the species, and of the rocks of the Portage about Ithaca, has shown that, stratigraphically, the species is probably limited to a mass of shales of not over three feet thickness, marked below by a stratum of argillaceous sandstone,—which in some localities is clearly defined and solid, of a foot in thickness, at other points indistinct by reason of the greater amount of argillaceous matter causing a looser and more shaly structure, —and marked near the top by a thin layer, three or four inches in thickness, of argillaceous sandstone.

The fossil appears most abundantly in fine soft shale, quite devoid of arenaceous material, just above the lower sandstone layer, and just above the upper four-inch layer. It occurs, also, but not so thickly massed, between the two sandstone layers; but only one specimen has as yet been seen in the upper sandstone layer.

In his Report on the Brachiopods of the State (l. c., p. 237), Prof. Hall remarks, that this is the only species of *Spirifer* from the Portage formation then (March, 1867) known to him, and as far as any record is published, no other *Spirifer* has been found as yet (1880).

At first glance this species recalls forms of later rather than earlier times, and the suggestion is strong to associate it with the Carboniferous species rather than with the Hamilton or earlier forms which precede it. There are many such forms in the upper Devonian,—both in America and Great Britain and Europe,—which point to a relationship between the two ages, quite impossible to reconcile with the idea of any great catastrophe as separating the two.

Comparing it with the Hamilton *Spirifers*, this is a well-marked species, not the only or the first unplicated, smooth species, but the first large one possessing these characters, and

in general appearance it is readily distinguished from any earlier form.

Comparing it with European forms of the Carboniferous, it appears as one of them; and in general *Spirifer lævis*, H. presents greater resemblance to the Carboniferous than to the Devonian representatives of the genus.

As a well-marked form, with a limited geological horizon, and appearing in a limited geographical area, *Spirifer lævis* is interesting in itself; and a study of its relations to the past, becomes especially interesting, on account of its appearance here in the Portage, as a new and distinct "species," and in its distinctive characters, seeming to belong to a type or form entirely new for the genus. It stands out prominently as a suddenly appearing "species;" and between it and the forms preceding it there appears, at first sight, to be a distinct gap. Without attempting to redescribe the species, it may be worth while to point out its distinguishing characters.

Form and Proportions.—The outline of the ventral valve, the one more commonly met with, is sub-circular or semi-elliptical, with prominent beak and broadly rounded margins at the cardinal extremities, the margins of the shell almost always crushed and generally distorted. Opposite the beak, the base of the sinus is generally folded under, and thus this margin appears truncated, especially in larger shells. The greatest width of the shell is in a line lying anterior to the cardinal line about as far as the beak extends posterior to it. Over this same line is the greatest elevation of the swollen valve.

The proportions of length to breadth are, as Hall mentions, "from two to three, or three to four." In specimens of which the sinus is preserved to the end, I find the distance measured on the outer surface of the shell, from the point of the beak along the groove of the sinus to its anterior margin, is very nearly equal to the greatest actual breadth of the shell. This line measures the actual length of superficial growth in the medial line of the ventral valve, and thus becomes a very fair unit of measurement for comparison, and can be determined as well in distorted as in uncrushed specimens.

Size.—The length of this median growth-line, in specimens of ordinary size, is about five centimeters, or about two inches. As an example of shape, I will give the proportions of a medium-sized specimen (No. 260) of my own cabinet, whose outlines are well preserved:

Median growth-line, - - - - - -	4.5	c.m.
Greatest breadth, - - - - - -	4.45	"
Total length of cardinal area, its extremities merely linear,	3.4	"
Greatest elevation of shell above the plane of the margins, -	1.2	"
In same plane, distance from hinge-area to extremity of beak,	0.6	"
Greatest separation of the two folds forming boundaries of the sinus, - - - - - - - -	1.4	"

Beak.—The beak is prominent, and arches over the cardinal area.

Cardinal area.—The cardinal area is short and high; when viewed perpendicularly to its surface, the convexity of the shell above the beak appears about equal to the elevation of the area, and it falls rapidly to a narrow linear area for the terminal part of the hinge-line.

Aperture.—The aperture is triangular, and in all perfect specimens is found to be covered with a pseudo-deltidium.

Pseudo-deltidium.—This pseudo-deltidium is triangular, and convexly arching outward and, in what seem to be normal specimens, has the form of an equilateral triangle, though in other specimens with short and very high area, the pseudo-deltidium is narrow, forming an acute angle at the top.

Surface.—The surface is in general smooth; only faint lines of growth appear until near the margin, where the surface is often coarsely imbricated by concentric lines of growth.

Obscure plications.—Hall mentions the fact of the obscure and undefined radiating folds occurring in older shells.

This is noticed to be a fact; and the only specimens in which these obscure plications have been observed (by the writer) are those from the *lowest layers* in which the species occurs. Further investigation may disprove the supposition, but as far as observation goes, the facts suggest that traces of radiating plications appear only on specimens from the lowest strata, *i. e.* at the first appearance of the species, and only on the largest and hence

most thoroughly developed specimens. We will refer later to other interesting facts in this connection, only mentioning now that wherever these traces of plications are found, they appear on the *marginal portions* of the shell, and never high up toward the beak.

There is still another character which is highly important, and it forms one of the most valuable criteria in tracing out the relations of the species. Hall, evidently, had not observed it, and I can find no printed evidence that any author has heretofore noted the fact next described.*

Concentric series of minute radiating lines.—The surfaces of specimens well developed, and which did not suffer from attrition before being safely covered up, show under a glass of moderate magnifying power, fine concentric rows of short radiating lines, such as are seen coarse and strong in *Spirifer fimbriatus* of the Hamilton and Corniferous, and in several other species of other periods, and which furnished Davidson the distinguishing character by which to separate the Devonian *S. curvatus*, Schl. from the Carboniferous *S. glaber*, Martin. It is surprising that Hall did not notice this fact when the strong resemblance to the British representatives of *S. glaber*, Martin, figured by Davidson, was specially mentioned by him.

Further comment will be made upon these points.

We have drawn attention to the few characteristic marks of this species:—To enumerate them, they are evident, as follows,

a. 1st, in the form and proportions of the shells;

b. 2nd, in the size;

c. 3d, in the prominence and over-arching of the beak;

d. 4th, in the short and high cardinal area;

e. 5th, in the triangular aperture covered by arched pseudodeltidium;

f. 6th, in the smoothness of the surface;

g. 7th, in the concentric series of minute radiating lines;

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* Since this paper was completed, and an abstract published, I learned that Prof. Hall had previously observed the surface markings of *Sp. lævis* referred to, and had already prepared plates illustrating the fact, for a work which is as yet unpublished.

May, 1881. H. S. W.

These are the data preserved for us in the rocks, from which we are to determine the *specific* character of the shell. These are all morphological characters, and the species they define is plainly a morphological species; and it is by study of these facts that the history and the relations of the species, and its true limits and nature, can alone be determined. A comparison of this with other forms reveals some very interesting facts.

First.—The second specific characteristic (*b*), namely, the size, is known to vary easily and rapidly under changed conditions of food and climate, and other environ-conditions. In a comparison of forms of different geographical or geological areas, the difference in size may be safely regarded as of varietal importance, but taken alone is scarcely of specific importance, using species in the strictly morphological sense.

In the present case, in the layer in which the species first appears, the individuals are very abundant,—and actually massed together,—the majority of them being as large as the average, some larger than any yet observed above the bottom layer; but also with these are many small individuals, less than half the size of ordinary specimens, and others still smaller, running down to minute ones, scarcely the size of a pin-head. In these smaller individuals, are seen characters relating them to varieties of *Spirifer fimbriatus*, Conrad, of the Hamilton beds below; but they are plainly young or immature forms of the *S. lævis* series, being found from the smallest through the intermediate to the normal adult *S. lævis*.

A young specimen of *S. fimbriatus*, C., from the Tully limestone of the upper Hamilton, is seen in the University collection, which could not be certainly distinguished, specifically, from the young of *S. lævis* of the Portage, if the two occurred in the same bed.

I am inclined to consider the forms called *Orthis subumbona*, in the 10th Regents' Report, and identified as *Ambocœlia* in the 13th Report, and as *Spirifer* in Hall's final Report on the Brachiopods (Pal. of N. Y., vol. 4, p. 234), as only an extreme variety of the typical form, called *Spirifer fimbriatus*, Con. It ranges throughout the Hamilton, but, as specific names are now applied may as well keep the specific name.

However, the normal type of *S. fimbriatus*, (see pl. XIV), of the Hamilton and earlier periods, is distinctly plicated, and the series of radiating lines are coarse, and the lines themselves strong and wider apart, and the species does not average half the size of a typical *S. lævis.* There is another fact suggestive further of the relationship : the variations noticed in the individuals of *S. fimbriatus* include an obscuring or obliteration of all those special characters by which the typical forms of the two species differ conspicuously from each other.

The form and proportions (*a*) vary in *fimbriatus* to those characteristic of *lævis*,—typical *fimbriatus* being much broader than typical *lævis.*

(*b*) The size is decidedly greater in *S. lævis ;* but the Corniferous representative of *fimbriatus* is larger than the Hamilton representative ; and for the great size of *lævis*, we must look to some cause not yet known.

(*c*) The beak is smaller and less over-arching in *fimbriatus ;* but in this species the beak is variable, and as the shape approaches that of *lævis*,—(*i. e.*, in the shorter specimens) the relative size of the beak is greater. In *lævis*, also, there are varieties found in which the beak is as small and low, proportionately, as in some specimens of *fimbriatus.*

The feature (*d*) is characteristic of *fimbriatus* as well as of *lævis.*

(*e*) The aperture is triangular and very similar in both ; but it is rare to find the pseudo-deltidium preserved in *fimbriatus ;* still, what traces there are of it lead us to presume that it was obtusely arching, as in *lævis.*

(*f*) The smoothness of surface in *lævis* is perhaps its most prominent specific character ; but the presence of obscure plications on the margin in large specimens in the lowest stratum, is strongly suggestive, and leads us to suspect that the ancestors of this form were plicated. If we study a complete series of *Spirifer fimbriatus*, C., we find the species, in its typical form, characterized by a few (the number varying) broadly rounding (the prominences varying), radiating plications ; and a common variation is the disappearance of the plication from the beak and swollen part of the shell, extending far down toward the margin; and occasionally an individual may be found of full size, but

entirely wanting radiating plications. The manner of disappearance is worthy of notice. The undulations of the surface, forming the plications, become lower and lower as the plications become obscure, but never in this way do they reach obliteration. We find them obliterated first in the part of the shell representing the earlier stage of growth—about the beak; this (unplicated) area becomes greater and greater until the plications are confined to the margins, and they are obscure and faint,—as in the rare specimens of *lævis*.

The formation of folds or plications is thus seen to be a process which, in the series of individuals under consideration, begins later and later in the growth of the shell, and in the last individual has scarcely begun when maturity is reached, so that only the margins are affected,—leaving the main part of the surface free from plication.

The facts that only the largest individuals of *Spirifer lævis*,—those whose growth continued the longest,—show any trace of the plications, and that whenever they are found, it is only on the margins of these large shells, are quite consistent with the supposition that *lævis* is traceable genetically to *S. fimbriatus* of the preceding period.

In regard to the seventh character (*g*), let us first read what Hall says of it in *S. fimbriatus*.

"The concentric striæ are studded with elongated nodes or tubercles, which are thus arranged in parallel bands, more or less contiguous, according to the distance of the concentric striæ.

"The elongate tubercles may perhaps more properly be regarded as interrupted radiating striæ, which, in the perfect condition of the shell, have doubtless extended in slender spines or setæ. (They are termed by Mr. Conrad short longitudinal striæ.)"

These "short longitudinal striæ" are very characteristic of *S. fimbriatus*, and much coarser and stronger than in any specimens of *S. lævis*, but showing a tendency to become finer and less strong in the smoother unplicated varieties of the former species.

It is a rather rare character among the species of *Spirifer*, and becomes a valuable mark in tracing relationship.*

The species *Spirifer fimbriatus*, Con., is seen to be a variable species of wide range. It is traced down as far as the Oriskany, and as Prof. Hall suggests, we may recognize related forms in *S. pseudolineatus* and *S. setigerus* of the Carboniferous; but in its so-called specific characters, it is the first of its type. In geographical range, it is recorded from New York,—throughout the State,—Canada West, Ohio, in the Mississippi Valley, and in Virginia.†

As a specific form, it seems to have reached its perfection in the Hamilton.

The comparison we have made between the two species *Spirifer lævis*, Hall, and *S. fimbriatus*, Conrad, appears to leave little doubt that the former is, strictly speaking, a descendent of the latter; and the tracing of the marks of relationship brings the latter into line with a series of forms reaching back to the Niagara Period and forward at least to the upper part of the Carboniferous age.

A study of the series of related forms has brought out many facts which may be interesting to students of Palæontology, and to some whose studies may cover a wider field; and in the following pages I will attempt to give in orderly manner the results of my researches.

A number of species have been considered, but those in which the marks of relationship appear most distinctly are the following:—

In the Niagara period, are—

Spirifer bicostatus, Vanuxem, *S. crispus*, Hisinger, and *S. sulcatus*, His.

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* See Plate XXXIV, Fig. 9, Suppl. to Brit. Permian Brachiopoda, Palæontological Soc. Publications, and Davidson's descriptions of the concentric rows of spines of *S. lineatus*, p. 275, l. c.

These tubular spines with double perforation I have detected for the first time in any American Spirifer, in a specimen of (?) *Sp. fimbriatus* (a fragment from the base of Chemung group).

† I have found fragmental specimens of clearly marked *Sp. fimbriatus* near the base of the Chemung, with the concentric rows of surface-markings, and with about the normal number of plications of surface.

S. crispus, His., of the Coralline limestone.

S. crispus, var. *simplex*, Hall, of the Niagara, in Indiana.

S. Vanuxemi (Vanuxem), Hall, of the Lower Helderberg Tentaculite limestone, and *S. cyclopterus*, *S. perlamellosus*, *S. octocostatus* and *S. modestus*, H., all of the Lower Helderberg.

S. Saffordi and *S. tenuistriatus*, of the same period.

S. tribulis, H., and rare exambles of *S. fimbriatus*, Con., from the Oriskany.

The various forms of *fimbriatus* of the Corniferous and of the Hamilton periods, which might have received several specific names if they were not so well represented in individuals.

S. subumbona, H., of the upper Hamilton, as well as of the calcareous bands at its base.

Spirifer lævis, H., of the Portage, and *S. prematurus*, H., in the Chemung further south.

In the Carboniferous, such forms as *S. pseudolineatus*, H., —*setigerus*,—*plena*,—*octoplicatus* and—*hirtus*, carry on the type in this country; while in Great Britain and Europe a like series extends from the Wenlock beds of the Silurian through to the Carboniferous, and perhaps beyond; but the specimens are not at my hand for a full comparison and tracing of the later history.

In the Wenlock and following Silurian beds, are the three varieties called *Spirifer elevatus*, Dalman, *S. crispus*, His., and —*sulcatus*, His. *S. granosus*, Vern., of Keyserling, in Russia may belong to the group.

In the Devonian, are *S. curvatus*, Schl., of the Ilfracombe beds and elsewhere; *Spiriferina cristata*, Schl., and *Sna. insculpta*, Phil., as defined by Davidson, are probably in the line, and Schnur's *aculeatus*, and the *S. curvatus*, of the Eifel, are also representatives.

In the Carboniferous, the various modifications of *Spirifer glaber*, Martin, and *S. sulcatus*, His., carry on the character of the main types.

Spirifer lineatus, with which Hall compares several of the Devonian forms in the United States, may be connected with this line; but from the limited study I have been able to give it, I am inclined to refer it to another series of forms, beginning perhaps in *S. radiatus* of the Niagara.

I have mentioned a number of well characterized species, *i. e.*, forms which taken in their separate geological horizon are distinguishable from other forms in the same horizon. In making a comparative study of them, facts of interest are brought out in regard to each, which may be laid before readers by presenting them in the form of notes on each of the species. *

It will be noticed, that I use the term species in the restricted modern sense, as a morphological species only. Our studies may throw some light on the nature of species in the broader and more theoretical sense.

Spirifer crispus, Hisinger (not of Linn.), (Vet. Akad. Hauslingen, tab. VII, fig. 4, 1826, figured by Davidson in Brit. Sil. Brach., pl. X, figs. 13—15), with the associated forms, is apparently the earliest type of *S. fimbriatus* and *setigerus*, etc., of later times in America, and of forms under other names in Great Britain, Europe and elsewhere.

This species is described by Hall as *Delthyris staminea*, in Geol. Rept. of 4th Dist. N. Y., pp. 105, 106, and figured, l. c. fig. 3, and later it was more fully described and figured, and referred to *S. crispus*, in Vol. 2 of Pal. of N. Y., p. 262, fig. 3, i–k, of Pl. LIV. Whether or not this form, with its closely related ones, is identical with those of the upper Llandovery beds, and up to the Ludlow formations in Great Britain, called *Spirifer crispus*, His., by Davidson, and *S. elevatus*, Dalman, of the upper Llandovery, these are without doubt the representatives on this side the Atlantic of the European spirifers included under the specific names *elevatus*, Dalman, —*crispus*, His., and —*sulcatus*, His., and present like variation and like similarity, and also were widely distributed and abundant.

The following are the main peculiarities of the species as

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* Further study has shown that the genus Spirifer began and continued in about four well-marked *kinds*, *i. e.*, types, with the variations of each.

The three principal types are *radiatus*, *crispus*, and *sulcatus*,—and I am inclined to regard *Cyrtia exporrecta*, Wahl. as the central type of the fourth kind.

The corniferous species *Spirifer maia* of Billings, although at first glance appearing to belong to the *S. crispus* kind, I think (I have not seen good specimens) is a representative of the *S. radiatus* combination of specific characters.

known in America, identified by Hall as the true *Spirifer crispus*, Hisinger. It occurs in the Niagara shales in the western part of New York State; most abundantly about Lockport and Lewistown.

1. It is of sub-rhomboidal form, rounded at the sides; the ventral valve is semi-circular. This peculiar shape includes a short hinge-line, either as short or shorter than the greatest width of the shell.

2. The valves are unequal in convexity, "very unequal," the ventral one extremely convex, the dorsal not so much so. (This character is also seen in well-preserved specimens of *S. lævis.*)

3. Beaks moderately extended and incurved over the hinge-area: they may be much separated, or approach each other closely, making—

4. A hinge-area, either broad and prominent or low and narrow; this latter being the case when the hinge is extended, and then the form approaches that of *S. sulcatus.* The normal or typical form of *crispus* may be considered as possessed of a high cardinal area, the extremities of which are short.

5. The aperture is triangular and rather narrow, and is not covered with a pseudo-deltidium, in specimens preserved. This is most likely due to the fact, that the pseudo-deltidium was not completely calcified in the living animal, and during fossilization was lost.

The radiating plications are few,—from four to eight,—but only slightly elevated and rounded, and often obsolete, and the inside casts are smooth. As to this variation, note *crispus* of the Coralline limestone, and the var. *simplex* of Indiana and the West, also the smooth type, *bicostatus.*

The radiating folds are marked by fine concentric lines; these, by aid of a magnifying glass, are seen to answer to Hall's description—"and upon the striæ, the surface is thickly set with minute setose points, giving a semi-striated appearance to the surface. This feature is not ordinarily visible, and it appears to have been abraded by very slight attrition." Hall's Pal. of N. Y., Vol. 2, p. 262. Hall finds no reason to separate this from the Swedish species, nor from that of the Wenlock of England.

S. bicostatus, Conrad, differs from *crispus* in the more dis-

tinct imbrication of the concentric striæ; in the fewer plications, which resemble rather one broad fold on each side of the sinus than plications, and these rarely reach the beak; the hinge-line is shorter, giving a shorter and rather high area, and the rounding of the lateral margins leads to the character observed in *lævis*, and other smooth forms—of a sudden curving of the striæ at the extremities.

This appears to be the type of the *S. lævis*, H., of the Portage, and *S. curvatus*, and especially *glaber*, Martin, of the foreign Devonian and Carboniferous; but here in the Niagara it is closely associated with *S. crispus*, may be readily con founded with it, and series of specimens connecting the two forms can be made so complete that theoretically we may presume the two are but varieties; but we must note particularly that the size of each of these Niagara species is very small compared with either *S. lævis* or *S. glaber*.

Spirifer sulcatus, Hisinger, is a name applied to specimens on the other side the Atlantic, which undoubtedly are but varieties of the typical form *crispus*, His., of which the peculiarities are a greater extension of the hinge-line, an increase in the number and abruptness of the plications, and a lower and more extended hinge-area, and with this, a less prominent beak.

In this country (and perhaps also in Britain and Europe), some of the specimens identified and described as *S. sulcatus*, His., are undoubtedly quite distinct from the group of which *S. crispus*, His., may be taken as the type.

If we take, then, the median form of *S. crispus*, His., of the Niagara as type, we see three distinct varieties:

1*st*. *S. crispus*, His., with its rounded plications, three or four at least on each side of the median sinus, short hinge-line, and shape rather broader than long; a moderate beak; area moderate but well defined, and not extending to the extreme lateral margin of the shell.

2*d*. *S. bicostatus*, Con., (and some specimens of *crispus*, His., the var. *simplex* of Hall,) in which the beak is prominent, the breadth nearly equal to the length, the surface either quite smooth, or with but one or two plications on each side of the sinus, and these not reaching to the beak, and, when present, the plications are broad and only slightly elevated folds; the

beaks overarching, area high and short, and decidedly shorter than the greatest width of the shell, and the striæ suddenly turning in to meet the shortened hinge-line.

3*d*. The type seen in some specimens of so-called *S. sulcatus*, His. The typical characters of this variety are an extended hinge-line,—a shorter shell,—the area low and produced laterally, the beak moderate and not overarching,—the plications more than four on each side of the sinus, and abruptly rounded and distinct. I would separate those with sharp angular plications and prominent imbricated concentric striæ, as a distinct species (probably the true *S. sulcatus*, His.), which present also the sharp and often considerably produced hinge-line and area.

These are the three prominent directions of variation noted in the first appearance of the combination of characters which marks either one of the varieties.

Davidson's species (see Brit. Sil. Brach., pp. 91, 92—98) from the Wenlock, etc., are identified somewhat differently from those of Hall. The ribs of *S. sulcatus* are not angular, as in Hall's species; and Davidson's descriptions, as well as his figures, show the close relationship between the three species called *S. sulcatus*, His., l. c. 91, Fig. 4–6, Pl. X; *S. elevatus*, Dalman, l. c. 95, Figs. 7—11, Pl. X; and *S. crispus*, His., l. c. 97, Figs. 13—15, Pl. X.

Davidson recognises the likeness of varieties of these species, and appears to regard them as distinct,—rather yielding to the custom of palæontologists than on account of certain marks of distinction (see l. c.).

S. crispus and *S. elevatus*, I think may be united, and while *S. sulcatus* may be distinct, as identified for part of the specimens so-called in Great Britain and America, I judge that this too, in part, is but one of the varieties of the typical form which appears with much variation in Britain and America, and yet, with all its variation, with well-marked "specific characters." Much more might be said in regard to this point, but I lack the specimens needed for examination; and without consulting the specimens themselves, we must leave the strict boundaries undefined, and simply recognise the presence of the specific form with all the variational peculiarities in Britain and Europe.

In *Spirifer crispus* of the other side of the Atlantic, we see

the same characters and peculiarities: the shape and its variations;—the hinge-line, as to relative length compared with that of the shell;—the area and the aperture with its extent and variation; the swollen nature of the valves and the greater prominence of the ventral valve;—the prominent median fold and the rounded nature of the side-plications, varying in number, but always few, and often being obsolete near the side-margin and on the beak. The surface markings, too, *i. e.* the radiating and concentric striæ, are characteristic,—the former being the prints or bases of systems of spines, only seen by the microscope. The size also agrees with that of the representatives in the Niagara rocks of America.

Before considering *S. curvatus* and related species, let us notice the two species provisionally put by Davidson in D'Orbigny's subgenus *Spiriferina.*

Spiriferina cristata, Schlotheim (sp.) var. (Brit. Dev. Brach., p. 46, Pl. VI, Figs. 11—15, also Brit. Perm. Brach., p. 17, and Carb. Monogr., pp. 38 and 226). Davidson expresses himself as not able clearly to distinguish this species from either *Sna. cristata* of the Carboniferous and Permian or *Spirifer crispus* of the Silurian; and he says—"The question of the origin and recurrence of the Spiriferina we are at present describing" (*Sna. cristata,* Devonian, l. c., p. 47), "is one of some difficulty, demanding considerable attention and further research. It is an exceedingly variable shell, being small (adult) in some localities or strata, while in others it has attained considerably larger dimensions" (at Lowe and Cornwall large, and at Dartington small). "It is my strong impression that we must look for its first appearance or origin in the Silurian time, and that it continued to be represented, with some slight modifications, in the Devonian, Carboniferous, Permian, and perhaps up to the Jurassic period" (l. c., p. 47).

Davidson identifies the Scottish Carboniferous *Sna. cristata* and *Sna. octoplicata* with this species, and these with Schnur's species *Spirifer aculeatus.* The species *Spiriferina insculpta,* Phillips (sp.) var. (Pl. VI, Figs. 16 and 17, l. c., p. 48), appears to be also closely related to these species.

In the Silurian monograph, we find the variety with angular plications, and more of them, called *S. sulcatus,* while *S. crispus*

has rounded ribs and shorter hinge-line (see *S. crispus*, His.). While this variety has persisted, also the variety in which the ribs became obsolete and the size increased, is common in Britain and Europe, in Devonian and Carboniferous strata; and a careful study and comparison of the American and European forms is much to be desired.

Spirifer glaber, Martin, of the Carboniferous, seems to have no resemblance to the *Sna. cristata* just mentioned; but if we look back into the Devonian, we find *Spirifer curvatus*, Schl. (Brit. Dev. Brach., p. 39, Pl. IX), which presents the characters of form, proportions and markings seen in that variety of *S. crispus* in which the ribs were obsolete and the hinge-line shortened, (and may not Fig. 1, Pl. VII, called *S. undifera*, be but a variety of *S. curvatus?*)

When we read Davidson's description, we learn that, except for the surface-markings, he would identify this species (*S. curvatus*) with the Carboniferous *S. glaber;* and when we compare our Devonian *S. lævis* with them, and note the close resemblance to the Carboniferous form of Britain, and besides discover the very surface-markings in question on our *S. lævis*,—I think we are justified in uniting the three species as varieties of one form.* We thus trace a supposed relationship (see, in

* Since this paper was written, Mr. Thos. Davidson, F. R. S., has very kindly sent me two specimens of *S. glaber*, Martin, from the Carboniferous limestone, Yorkshire, showing concentric and radiating striæ. Mr. Davidson writes that they are the only specimens he had seen possessing these surface-markings.

One specimen is beautifully perfect, and shows very fine concentric striæ marking the whole surface.

The microscope (a pocket glass) reveals what appear to be very minute and faint pittings of the surface, very close together, arranged in lines running diagonally and crossing each other. The other specimen shows coarse radiating striæ, convex, and in several cases dividing into two, which continue parallel and together to the margin. They appear to run deeper under the surface as they approach the margin, and their exposure appears to be caused by the scaling off of some of the shell near the margin. The former are undoubtedly the markings noted by Prof. L. de Koninck, and mentioned by Davidson in Suppl. to Brit. Carb. Brach., p. 274. "On observe à sa surface des ponctuations bien marquées et disposées en quinconce sur presque toute son étendue."

this connection, Hall's remark in first clause of p. 237, 4th vol., Pal. N. Y.) from our *Spirifer lævis* through *S. fimbriatus*, and others, to the Silurian *S. crispus*, and recognise the same grades and variations in the forms appearing on the other side of the Atlantic, up to the Carboniferous forms.

What does this series of observations suggest?

Whatever theoretical description we may give to species, here are, in the first place, an abundance of individual organisms whose remains are found in the Upper Silurian rocks of Europe, Great Britain and America, presenting a few clearly-marked distinctive characters, variously developed in the individual forms, but so grading in the several varieties as to cause careful naturalists to associate them as varieties of a single species. There are well-marked typical characters distinguishing all the individuals from other forms of the same genus, together with great variability of the characters themselves. In the upper part of the Upper Silurian we find the same typical characters, with a greater permanence of one or other of the variations; but still, in the variations occurring later in the Corniferous and Hamilton, we have the main type represented with some variations strongly marked and seeming to be fixed, but still recognised as varieties simply.

In the Portage, we see under peculiar conditions a solitary race of the type with greatly exaggerated size,—a luxuriant form but still presenting the typical characters of the second varietal type.

In the Carboniferous we meet with several well-marked varieties, but no feature which did not appear in the early form except large size, which is evidently a mark of good nourishment and other good conditions of growth. This latter seems to be a character of most of the Carboniferous forms of Brachiopods which have lived on from earlier times. There may be unknown characters to distinguish these forms, but of the characters that are preserved we have evidence that in the earliest form, the type, *S. crispus*, His. of the Niagara, etc. (with its varieties), are found all those which afterward appeared in the later representatives.

These characters appeared in combination in a single group

of individuals, living in one class of conditions, in such circumstances as seem to warrant our calling them one physiological species in the sense of being able fertilely to cross with each other, this being the explanation of the gradation of one form into the other noted by Davidson. This presumed—that we had a single species to begin with—we have, by intercrossing and by local conditions modifying the offspring, well-defined groups, which would be called races if we knew their history, but which are called species because they appear at so widely divided geological periods.

These separate groups, however, *develop no new characters*, but in those appearing at each stage are seen fixed and apparent only varietal characters of the original form, with such modifications as poor, or rich, or varied food may give to animals we now may modify. There is nothing of a specific character evolved in this series of forms which did not appear in the first forms, but there is every evidence for the belief that the species has lived through this long geological time without losing its character, and that all that has resulted from great time and change of conditions has been the fixation into race-groups of the original variable characters of the species.

The species, at its first appearance in the Silurian, presented a decidedly new combination of characters for the genus, and also much variation. When once these specific though variable forms appeared, they lived till the variations which could be played upon them were exhausted; and the species ceased to live and became extinct either near the close of the Carboniferous or not till later in the Mesozoic.

Some of the races or varieties may die out, but they reappear again and again till there are such strong contrasts that it is difficult to see even generic resemblance between them.

The variety or so-called species of the Niagara Period, which seems most closely to correspond to the form of *S. lævis*, is that mentioned in Vanuxem's Report of the 3d District of New York, p. 91, and called by Conrad *Orthis bicostata*, but not described by him (see note in Pal. N. Y., Vol. 2, p. 263). This was evidently a local variety, as Hall fails to discover it at any considerable distance from the original locality; and what is remarkable is the similarity of conditions, as seen in the *isolation*

of the form, the *concretionary* structure of the beds, and the relative *abundance* of the individuals in the case of both species (*S. bicostatus* and *S. lævis*). Hall speaks of the only locality in which he has discovered this peculiar form, as "Vanuxem's locality in Oneida Co." He finds them on the surface of a thin layer of limestone. Vanuxem describes the species as occuring in "slate" (shale?); and as in the case of *S. lævis,* so of *S. bicostatus,* Hall failed to find perfect specimens.

The distinction observed by Hall, and upon which he bases the specific identity of *S. bicostatus,* is the absence or partial obliteration of the radial plications; when present, these are obscure or at the margins.

This character, only carried to a greater extreme, is recognized in *S. lævis.* However, as far as my observation goes, the presence of plications at all, in the latter form, is confined to a few overlarge individuals occurring in the lowest known layers in which the species is found. I have not seen the character on any specimens occurring in strata above that in which it first appears. Whenever the plications are present, they appear as rather faint undulations of the margin, extending rarely as far as half way to the beak. May we not reasonably regard them as the trace of ancestral plications, seen as a variable character in *S. fimbriatus,* here becoming obliterated? It is not the beginning of a new character, but the dropping of one of the typical, though variable characters of the old but still continuing race.

When we look forward to the Carboniferous representative we see *S. glaber,* with occasionally a trace of plications on the margins (see Davidson's monograph). The smooth unplicated form is a variety of one which was typically plicated. *S. crispus* and its full complement of varieties appear, so far as this character is concerned, to run through all grades of development at the very outset among the Niagara representatives.

Hall also speaks of the shorter hinge-line, and the abrupt curving of the striæ at the extremities,—two characters which are associated with each other,—a fact suggesting their relation (See Plate XIV.). We explain it in the following way:—

We presume that normally, as in the typical form, there is greater lateral extension of the hinge-line than in the unplicated forms,—and with this character, a straightening out of the con-

centric lines of growth at the lateral extremities of the shell; with the obliteration of the longitudinal plications, there is a co-ordinate expansion of the front and lateral margin, causing a relative shortening of the cardinal margin and a shorter bending of the concentric striæ to meet it at the extremities,—and at the same time an increased growth upwards of the hinge-area. So that we find high area,—short hinge-line,—abrupt curving of the lines of growth at the cardinal extremities,—and tendency to the obliteration of radiate plications,—to be co-ordinate features of the typical form whose history we are here studying.

By examination of other Spirifers, we discover great variety of shape, due to variation of hinge-extension and elevation of area, with sufficient constancy of other characters to constitute good species:—for instance, *S. mucronatus*, *S. medialis* and *S. disjunctus*, and the allied forms to which each may be supposed to stand in the relation of types. A comparison of the varieties of each suggests that the typical form of *S. mucronatus* has a widely extended hinge, low area, and produced extremities;—that the type of *S. medialis* has a shorter hinge-line, not produced into a point, with moderately high area.

A reference of the Portage *Spirifer lævis* directly to an origin in the *S. fimbriatus* of the preceding period, seems to need no argument further than the presentation of the facts, and a comparison of it with the various forms, earlier and later, with which it is most closely related. But a deeper study of the facts leads us to an equally clear conclusion that *S. fimbriatus* is only a *variety* of still earlier forms, and that the characters marking each variety appear as variational forms of the early type, and that during the passage from one to the other no assumption of new characters has taken place,—such as would not be regarded as purely varietal among living organisms, consisting in the obliteration or obscuring of prominent characters in some of the later representatives. An examination of Carboniferous forms shows the continuation of each of the typical characters in some representatives of the or'ginal stock.

There is no evidence of crossing of breeds to produce new varieties,—but merely a localising and interbreeding of varieties, to the production of greater prominence and fixity of certain characters.

The study of these Spirifers, in their historic relations, furnishes evidence of the persistence of specific characters in a variable condition, for which the limits of variation seem to be already fixed in the primitive form. The prominent primitive varieties appear distinctly here and there along the geological periods marking the life of the species, but neither pass out of existence nor become materially modified.

The length of time is from the Upper Silurian, near the beginning of the life of the genus, to the Carboniferous, and it may be beyond,—extending over nearly three-quarters of the time in which the genus lived.

The following is a tabular view of the relations of the Silurian and Devonian forms of which *Spirifer crispus* of the Niagara in New York is the type; the tracing of the history through the European forms and higher into the Carboniferous is reserved for further study. In the table, lateral extension is expressive of the morphological variations; each line represents one of the geological formations, which are arranged in their natural order; and the name of each species is placed in the position on the line representing its supposed relation to the typical form of *S. crispus.*

Chemung					prematurus
Portage					lævis
Hamilton				fimbriatus	subumbona
Corniferous				fimbriatus	
Oriskany			tribulis		
Lower Helderberg	N. Y. & Tenn.		Saffordi (pars.)		
	Maryland			octocostatus	modestus
	New York		cyclopterus (pars.)		
	New York,			Vanuxemi	
Niagara	shale				crispus
	limestone	sulcatus (pars)		crispus	bicostatus.

XI.—*On the Geology of Richmond County, N. Y.*

BY N. L. BRITTON.

Read April 4th, 1881.

Richmond County, or Staten Island, is the most southeastern portion of the State of New York. It is bounded on the north by Newark Bay and the Kill von Kull; on the east by the Upper and Lower Bays of New York, and the Narrows; on the south by Raritan Bay, and on the west by Arthur Kill. The area thus enclosed by these bodies of water forms an irregular triangle, and according to the best authorities contains about fifty-nine square miles. Its population, as given by the census of 1880, is 38,994, or 661 per square mile. Its length is thirteen and one-half miles, and its breadth about seven miles.

Topography.—The surface of the county is decidedly rough. A range of hills, having an average height of over two hundred feet, extends from the northeastern extremity at New Brighton, through the central part of the island to the county-seat, Richmond. These hills are six miles long, vary from one and one-half to two and one-quarter miles wide, and are capped with magnesian rocks.

Another well-marked series of hills begins at the Narrows, and ranges westwardly until it meets the first mentioned ridge near Garretson's Station. It follows the course of this ridge as far as New Dorp, and there diverging from it runs in a southerly direction to Prince's Bay. Here these hills bend to the westward for a short distance, but again take a southerly course and end on the shore of Arthur Kill opposite Perth Amboy. This second series of hills is about one mile and a half wide, near the Narrows, and rises to a height of one hundred and fifteen feet in places, while between the Great Kills and Prince's Bay their width is as great as three miles, but they are seldom over seventy-five feet high. These elevations are composed of rounded bould-

ers and pebbles, gravel, clay and sand,—with little or no order of arrangement,—which materials have been brought from the north and northwest by the great glacier which, in post-tertiary times, overspread North America south to about the fortieth parallel, and had its southern extension along the Atlantic coast on Staten Island. East of the Narrows, these hills form the backbone of Long Island; and west of Perth Amboy, they have been traced entirely across the State of New Jersey, and indeed all the way to Missouri and Kansas. They are what is known as the terminal moraine of the North American glacier.

East of the ridge of magnesian rock, and south of the moraine, we have some nearly level plains; these are well shown near New Dorp and Garretson's Stations, and again at the extreme southern end of the island. The surface is also quite level from New Springville to Mariners' Harbor.

Extensive areas of salt meadow occur along the Lower Bay near New Creek and the Great Kills, along Arthur Kill from Rossville to Port Richmond, and small patches near Tottenville.

There are no streams of very considerable size on Staten Island, but brooks and ponds are abundant. The largest of the latter is known as Silver Lake, and is situated high up on the magnesian hills, one mile and a half west of Stapleton.

According to the observations of Mr. Charles Keutgen, the total rainfall in inches for the last ten years, at Stapleton, has been as follows:—

1870:	38.38	1873:	53.09	1876:	46.09	1879:	47.16
1871:	53.45	1874:	49.68	1877:	42.90	1880:	37.34
1872:	45.00	1875:	45.00	1878:	58.62		

Literature of the Subject.—The subject of the Geology of Richmond County has been considered principally by the following writers:—

W. B. Mather, in the "Geology of the First District of New York," refers to Staten Island in a number of different places. Mather considered the clays and sands of the southern part of the island to be of Tertiary age, and the magnesian rocks to be of igneous origin; both of which conclusions are now replaced by others, probably nearer the truth.

Issachar Cozzens, Jr.: "A Geological History of Manhattan or New York Island," N. Y., 1843. This book gives a section across Staten Island, and a description of the different formations found thereon.

Prof. Geo. H. Cook, in the "Geology of New Jersey," 1868, and in "Report on Clays," 1878, refers to the serpentine, traprock, sandstone and clays of Staten Island, and to the terminal glacial moraine crossing it.

Geology.—We have within the limits of our territory, strata of Archæan, of Triassic, of Cretaceous, of Quaternary, and of Modern Eras; these will be considered in the order of their ages, beginning with the oldest.

Archæan Strata.

Granitic Rocks.—True granite occurs on the shore of the Upper New York Bay, about four hundred feet southwest of the Tompkinsville steamboat landing, and directly in front of the old building known as Nautilus Hall. The surface of rock exposed at low tide is about eighty feet wide by fifty feet long; at high-water mark the rock disappears beneath a hill of drift some fifteen feet in thickness. A little more of the same rock is exposed at a point about two hundred feet south of the main outcrop; but everywhere else on Staten Island the granite is covered by newer formations. There is reason to believe, however, that it underlies the magnesian rocks, and extends in a belt of undetermined width all around the eastern edge of them, covered by the glacial drift and Cretaceous strata to an unknown depth; and that the same belt continues in a southwestwardly direction to Arthur Kill, and thence across the State of New Jersey to Trenton, where it again comes to the surface. The approximate position of this belt of metamorphic rocks is shown on the accompanying map (Plate XV).

At the exposure at Tompkinsville this granite is very coarsely crystalline in structure, and for that reason could never be satisfactorily employed for building purposes, even were it accessible in quantity. The feldspar is orthoclase, occurs in large masses, and is greatly in excess of the other two constituents; the quartz varies in color from dark brown to nearly white; what mica

there is, appears to be muscovite. In places, the last named mineral is absent, the rock being then a kind of pegmatite or graphic granite. No stratification is observable, but the surface of the rock outcrop dips about fifteen degrees to the east. Mather calls this granite primary, and to the best of our present knowledge it belongs to the oldest geological formation in North America.

Steatitic Rocks.—As before mentioned, magnesian rocks, serpentines, form the tops, at least, of the main series of hills on Staten Island. It is probable that this rock originally was of very considerable thickness, for a large amount must have been removed by erosion; but yet no granite nor gneiss, which are assumed to underlie it, has been seen in place within the serpentine area, which is estimated at about 13.5 square miles. The present thickness it is impossible to estimate accurately, but judging from the exposures, I should place it over one hundred feet.

The most eastern exposed boundary of the serpentine is clearly and unmistakably marked by a series of very sharp slopes, which are nearly continuous from Tompkinsville to Richmond, and in some places are as straight and regular as they could be constructed. This regularity of the slope seems to be quite characteristic of these hills, and is not the least element of their beauty. How far east of the foot of these hills the serpentine extends is not known, but it is probably not a great distance, as the granite at Tompkinsville occurs within a few hundred feet of it. The southern end of the ridge descends rather gradually, and near Richmond is lost under the Freshkill marshes. The western boundary of the formation, or more properly the eastern limit of the Triassic sandstone which rests upon it, cannot be accurately located, as there are no outcrops, and the line as drawn on the map must be considered as only approximately correct.

The magnesian rock varies in color from light green to nearly black, and in texture from compact to quite earthy—much of it being fibrous. Its specific gravity is about 2.55, and in chemical composition it is all a hydrated magnesian silicate. The best exposures are at several places around the base of Pavilion Hill at Tompkinsville; in cuttings for streets in the village of New

Brighton; near the school-house at Garretson's Station; on Meissner Avenue near Richmond, and near Egbertville. The highest point of the ridge is nearly opposite Garretson's Station, and about half-way across the hills, where the elevation, as measured by an aneroid barometer, is four hundred and twenty feet.

There are a number of interesting minerals associated with the serpentine rocks; the following species and varieties have been collected at Pavilion Hill, and in New Brighton:—Compact Serpentine, Fibrous Serpentine ("Amianthus," "Chrysotile"), Marmolite, Silvery Talc, Apple-green Talc, Gurhofite, Dolomite, Calcite, and Chromite. Pink Talc and Deweylite are reported by Prof. D. S. Martin, and Magnesite by Prof. Dana (Mineralogy, 1868, p. 774), as found on Staten Island. It is stated by Mather that magnesic hydrate (Brucite) occurs there, but none has been found recently. The fibrous variety of the serpentine has been very generally known as asbestus; this mineral, however, is properly a fibrous amphibole, and does not occur on Staten Island. These minerals must be regarded as products of metamorphism, and were formed during the period when this action was in progress.

The metamorphic rocks of Staten Island are apparently a southern continuation of those of Hoboken, N. J., and New York island; the facts from which this conclusion is drawn are as follows:

First.—The strike of the rocks is nearly the same at both places, and the direction of the Staten Island ridge would, if prolonged, meet the Hoboken exposure of serpentine at Castle Point.

Second.—The serpentine lies west of the granitic rocks at both places.

Third.—Although the texture of the serpentine at Hoboken and that of Staten Island is slightly different, yet their chemical composition and associated mineral species are very similar.

Fourth.—It is highly probable, though not proven, that the

serpentine at Tompkinsville overlies the granitic rocks as it does at Jersey City. This can only be definitely ascertained by borings, as the contact of the two rocks cannot be observed. We have the negative evidence, however, that were the serpentine *older* than the granite, the latter would probably be found in greater quantity, and in more localities than it really is. Hence the probability is that the two rocks have the same relative vertical position on Staten Island that they have at Jersey City: and they are so indicated on the accompanying maps and sections (Plates XV and XVI).

Fifth.—Ellis and Bedloe's Islands, in the Upper Bay, are directly between the two outcrops on the line of strike, and are said to be underlaid by gneiss; but no very definite information is obtainable on this point.

As to the origin of the serpentine rocks, I have no new theory to advance, and consider the one which regards them as metamorphosed highly magnesian limestones to be more in accordance than any other with the facts as observed. The reasons for this opinion are as follows :—

First.—It is highly improbable that they were igneous in origin, because they contain about fourteen per cent. of water, are associated with gneissic rocks which we know are metamorphic, and are stratified,—although the stratification can only be distinguished at a few places, and there not very plainly, on account of the cleavage planes which cut the rock in all directions.

Second.—They are certainly not unchanged sediments, because there are no magnesian silicates known to be formed as sediments on such a large scale as these strata present; therefore they must be either metamorphosed sediments or metamorphosed metamorphic rocks.

Third.—These rocks could not have been sandstones or shales, because they would have become quartzites or feldspathic rocks by metamorphism; and while serpentine certainly is the result of the decomposition of hornblende in some cases, the extent of the formation on Staten Island would render this method of

formation very improbable; hence, by this method of reasoning, we have nothing but limestone to refer the original condition of these strata to.

Fourth.—In addition to these negative considerations, we have the direct positive evidence that strata of magnesian limestone gradually passing into serpentine have been observed (see Jukes' Manual of Geology, page 167), and that the presence of lime-minerals in the rock may be regarded as indicative of the former presence of greater quantities of calcic carbonate, which has been removed by the dissolving action of the metamorphosing waters, which doubtless held carbonic acid and silica in solution.

We may then outline the probable origin of these rocks in the following manner:—The strata now consisting of serpentine were deposited as highly magnesian limestones; by metamorphic agencies this material has been brought in contact with highly heated carbonic acid and silica-bearing solutions, which, by removing the greater part of the calcic carbonate, and altering the magnesic carbonate to a silicate, have left the rocks in the condition of hydrated magnesian silicates. During or at the close of this period of metamorphism, the eastern edges of the strata were tilted up, forming an anticlinal axis, while the extension of the formation to the westward was subsequently covered by the shale and sandstone deposited from the Triassic sea.

The true geological age of this belt of metamorphic rocks, which runs through Staten and New York Islands, extends far northward through the New England States, where it has a wide expansion, and has been traced southward as far as North Carolina, is not definitely known. There have been three principal theories advanced in regard to their antiquity; these are—

First.—That these rocks are of the same age as the Highlands of New Jersey and the Adirondack Mountains, or of Lower Laurentian age.

Second.—That they belong to the so-called Montalban system, one of the several divisions of the Upper Laurentian distinguished by Dr. T. S. Hunt and others.

Third.—The theory recently advanced by Prof. J. D. Dana (Am. Jour. Sci., [III] Vol. XX, pp. 21, 194, 359, 450), in which he claims that they are of Lower Silurian age. My own opinion is, that they will ultimately be found to be Laurentian, and only another fold of the strata forming the New Jersey Highlands; but the object of this thesis is not to discuss this much-disputed point in American geology.

Triassic Formation.

Strata of Triassic age extend over the parts of the county bounded by the assumed western edge of the serpentine rocks, the submerged gneissic belt, Arthur Kill and Newark Bay. This area contains about 14.5 square miles. The rocks consist of red ferruginous shales and sandstones, which dip to the northwest, and are broken through by a dike of diabase or trap-rock. They are in part the eastern extension of the Triassic strata which cover such a large portion of New Jersey.

Shales and Sandstones.—These rocks are exposed at but two places, to my knowledge, and there in but very small quantities. These are on Shooter's Island, at the mouth of Newark Bay, and on the adjacent shore, and were recorded by Mather. Here the strata consist of shaly red micaceous sandstone, differing in no essential particular from that so abundantly exposed in Eastern New Jersey.

No fossils have hitherto been found in these rocks on Staten Island, and the surfaces exposed are not sufficient to warrant any great expenditure of time or labor in search for them.

Diabase,—Trap-rock.—The diabase ridge that disappears beneath the Kill von Kull at Bergen Point, N. J., cuts through the red sandstone of Staten Island from Port Richmond to the Freshkill marshes, and appears as a long, low, round-backed hill, having a general strike of S. 40° W., thus being nearly parallel with the serpentine. Towards its southern end, its elevation is so little more than that of the sandstone that the position it occupies cannot well be distinguished. The length of this diabase outcrop is about five and three-quarter miles, and

its width, measuring from its assumed furthest eastern extension to where the sandstone covers it, averages less than one half mile. Both the eastern and western boundaries of this rock, however, are so obscured by drift that their exact positions cannot be determined, and the outcrop may be wider or narrower at any point than is indicated on the map.

The only places at which the diabase is exposed so as to be easily studied, are at and near the so-called "granite" quarries at Graniteville, and near Port Richmond. The rock is a not a granite, but a coarsely crystalline diabase, mainly composed of augite and a triclinic feldspar, which is probably labradorite. It has been found in well-diggings within the area indicated on the map, in the water near the junction of the Fresh Kills and Arthur Kill at Linoleumville, and outcrops near Chelsea, on the road to Springville. It will be noticed that Linoleumville is just at the northern edge of the submerged Archæan belt, and near the junction of the Triassic and Cretaceous formations. The same relative position of the rocks may be seen where this trap-sheet again comes to the surface, as it does about six miles southwest of the city of New Brunswick, N. J. In fact the trap-dykes seem to shun the exposed Archæan rocks and cling closely to the Triassic, none being found outside of the red sandstone area.

The explanation of this curious fact is, as has long since been pointed out, that the strata composing the filling of the Triassic basin are weaker than a like amount of the metamorphic rocks surrounding it, and hence offer less resistance to the intrusion of trap-dykes, which consequently passed through the sedimentary rock rather than through the harder, stronger gneisses and granites which border it. Now, between the New Jersey Trias and that of the Connecticut Valley, we have a fold of these metamorphic gneisses and granites, but not a single trap outburst. This would seem to indicate that this fold existed before the deposition of the sandstone and the subsequent intrusion of the diabase, only very much higher than it is now; and hence it is improbable that these Triassic rocks ever covered the Archæan folded strata, forming a Triassic arch from New Jersey to Connecticut, as has been supposed by some geologists; for, we should expect, if the Archæan rocks had been folded *after*

the deposition of the sandstone upon them, and the latter rock subsequently removed by erosion, to find the intervening space between New Jersey and Connecticut cut by trap-dykes, while in fact none have yet been observed.*

Cretaceous Formation.

The Cretaceous formation, more or less covered by glacial and modified drift and salt meadows, extends through all parts of the county lying east and southeast of the Archæan rocks. The area underlaid by it is therefore about 28.5 square miles.

The strata consist of beds of variously colored clays and sands, dipping slightly to the southeast, and having a general strike of about S. 45° W. They are a direct continuation of the "Plastic Clay" division of the Cretaceous, so named by the New Jersey geologists, and lie at the base of the formation in eastern North America.

South of the terminal glacial moraine, the strata are generally covered by a deposit of grayish-yellow sand and gravel of variable thickness, which is known as the Yellow Drift; this is only seen on Staten Island, in the vicinity of Tottenville, for the area southeast of the moraine near New Dorp and Garretson's is covered with modified drift, imperfectly stratified.

These Cretaceous strata of clay and sand in all probability extend eastward from Richmond County on to Long Island, and perhaps underlie the latter throughout nearly its entire extent. The clays are white, yellow, brown or black; they appear on the surface at a number of places, and the purer varieties have been extensively used in the manufacture of fire-brick, drain-pipe, gas-retorts, and other refractory ware.

White clays outcrop on the road just north of Rossville, at various places south of Rossville and near Kreischerville, along a stream near Prince's Bay; they have been noticed near Gifford's, and are said to occur at the bottom of a well near New Dorp. They will probably be found at other places.

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* For a full discussion of this "Triassic Arch" question, see I. C. Russell, in Annals of this Academy, Vol. I, 1878, p. 220, and Vol. II, p. 27, 1880.

The white fire-clay is sometimes associated with the so-called "kaolin." This material, which is very incorrectly named, consists of a mixture of white quartz sand with small amounts of white mica and clay, and sometimes grains of feldspar; it is known as "kaolin" throughout the clay district of New Jersey, but of course is not a kaolin, as this term is only properly applied to clays formed by the decomposition of feldspathic rocks in place. An analysis of this substance taken from the pits of C. A. Campbell & Co., near Rossville, made in the laboratory of the Geological Survey of New Jersey, and published in their Report on Clays, 1878, is as follows:—

SiO_2	92.70 per cent.
Al_2O_3	5.70
H_2O	0.70
K_2O	0.35
	99.45 per cent.

From this association of "kaolin" and fire-clay, it is supposed that the pits hitherto opened on Staten Island belong to the South Amboy fire-clay bed. These excavations are all south of Rossville, and quite close together. Assuming that these clays do belong to this bed, then those which outcrop north of that village may indicate the position of the Woodbridge fire-clay bed, which lies north of the first-mentioned one in Middlesex Co., N. J. From its position, the clay near Prince's Bay will then belong to the South Amboy bed, and that at Gifford's to the Woodbridge bed. But these are merely suppositions. So far as is known, the strata immediately underlying Tottenville and the extreme southern end of the island consist of sands only, no clay having yet been dug in that vicinity.

The extension of this formation to the east is indicated by an outcrop of buff-colored clay on the shore of the Lower Bay, about one half-mile south of the Elm-Tree Lighthouse. It will be noticed that all the pits from which clay has been taken are in the region between Rossville and Kreischerville. This does not prove by any means that clay occurs only in that neighborhood; on the contrary, the probability is that the beds extend interruptedly across the county, but are deeply covered by the

drift-hills of the moraine, which cover all the territory assumed to be underlaid by the clays, except that portion where pits have been excavated, which is northwest of the moraine, the ice-sheet having flowed over, or perhaps partly around it.

Interstratified with, and overlying the clays and sands, there are found thin beds of Limonite iron ore of limited extent; this substance frequently cements the sand and gravel, and forms a conglomerate of variable coarseness. Hitherto this iron ore has not often been discovered in sufficient quantities or of sufficient purity to warrant its use in the manufacture of iron. Lignite and pyrites are frequently found in the clay excavations.

The former substance may also be seen on the shore of Arthur Kill near Rossville, and in a ravine a little northeast of the village, after slides of the banks occur; it is generally impregnated with the pyrites, and with copperas after exposure to the air. As the lignite dries, it cracks up into little pieces, thus destroying the texture of the fossil wood composing it, and making it very difficult to retain good specimens. No fossil leaves or shells have been taken from the clays of Staten Island, but it is not improbable that they will be found at some future time, when the excavations are more advanced than at present. They are more likely to be found in buff or dark colored clays than in fire-clay. The leaves are of great interest, as they represent the first appearance of angiospermous plants on the earth. Large quantities of them have been collected at South Amboy and other places in the clay district of New Jersey.

Origin of these Deposits.—As these beds are composed of fragments of quartz, mica and clay, or decomposed feldspar, it is evident that they are the products of the disintegration of gneissic or granitic rocks. That they have not been formed in place, but have been deposited from suspension in water, is proved by their stratification and by the assorted state of the materials composing them. That the waters which deposited the clays were fresh, is indicated by the absence of fossil marine organisms, and the presence of shells apparently allied to the modern fresh-water genera, in the clays of New Jersey.

There has been considerable discussion in regard to the position of the gneissic rocks; it would seem probable that the

metamorphic rocks already described as lying just northeast of the clays, have furnished some if not all of the material for their formation. These rocks lie immediately between the Triassic and Cretaceous, and were probably very much higher in those epochs than they are now, for they formed in part the southeastern boundary of the Triassic sea.

The decomposition of the gneiss would produce the materials composing the strata of sand and clay which were deposited in basins along the coast, the strata lying nearest to the rocks being first deposited.

Where the Cretaceous formation is not covered by glacial drift, there is now living on it a peculiarly southern vegetation. I have called attention to this fact in the Bulletin of the Torrey Botanical Club, VII, 81, by showing how the characteristically southern flora of the New Jersey pine-barrens extends into Richmond and Suffolk Counties, N. Y., but only on the sands of the Yellow Drift.

Quaternary Epoch.

Glacial Drift.—Deposits of material brought from the north by the ice of the glacial epoch, are found over the greater part of Staten Island, but do not entirely overspread it.

The most southern terminal glacial moraine crosses Staten Island from the Narrows to Tottenville, and is distinctly marked by a continuous line of hills, the size and appearance of which have been already described. These hills mark the farthest southern extension of the ice-sheet, and the line along which the glacier deposited most of its burden of boulders, pebbles, sand and clay, which it had torn from the rocks in its southward journey. In many places these hills have the peculiar lenticular form which they assume on Long Island and in the Eastern States. The dotted line on the map extending westwardly from Clifton and ending at Tottenville, represents the most southern and eastern position of the boulder-drift on Staten Island, and has been quite accurately determined. The moraine has been partially removed by the wash of the waves from Prince's Bay northward to near the Great Kills, leaving a bluff of variable height.

The glacier moved across Staten Island in a south-southeasterly direction; this is proved by the markings on the trap-rock near Port Richmond, which have about that bearing; the surface of this rock is also smoothed like portions of the Palisades and Newark Mountains. There are no such markings on the serpentine rocks, because they are too soft to retain them; the ice extended over their whole extent, however, with the exception of a small area on Todt Hill, which is east of the moraine.

North and west of the morainal hills, the drift is not so abundant, rarely forming hills of any considerable size; but boulders are to be found over all this area, except where it is covered by newer formations, and the soil is often very clayey.

Diabase of various degrees of coarseness is the most abundant rock in the drift; this has been carried from the Palisades and the Newark Mountains, and probably in part from the trap-dyke on Staten Island itself, and is found over the whole drift area.

Gneiss of various kinds, largely syenitic, is perhaps the next most abundant rock, and occurs often in very large masses. One of these large boulders rests directly on the top of Fort Hill, New Brighton; another along a roadside near Pleasant Plains, and a third worthy of notice, in a field near Huguenot.

Moderately large boulders both of trap and gneiss abound on the moraine between the Narrows and Garretson's; the gneiss has come either from the New Jersey Highlands or from much farther northward, and perhaps in part from New York Island. Triassic red sandstone, carried from New Jersey or the northwestern parts of the county, is often met with; a specimen impregnated with copper salts was obtained from the bluff at Prince's Bay. This locality has yielded many other interesting specimens illustrating the material brought by the glacier. Among these may be mentioned Potsdam sandstone, containing the borings of the worm *Scolithus linearis;* a number of rocks of Helderberg limestone, containing *Strophomena rhomboidalis, Strophodonta Beckii, Spirifer macropleura,* and other brachiopods, with quantities of crinoid stems; a specimen of granite containing graphite; a cherty rock which may belong to the Corniferous, and a conglomerate of uncertain age, but perhaps of the Oneida epoch.

A boulder of Hamilton limestone, containing *Spirifer mucronatus*, occurs near Richmond, and a rock containing galena was found in some excavations near New Brighton.

The ice-sheet passed entirely over the clay-beds of the Cretaceous formation in the vicinity of Rossville, apparently without deteriorating them to any great extent. At first sight, it would appear that these soft unconsolidated strata would have been greatly eroded and almost entirely removed down to the bed-rock, by such an immense mass of ice moving over them ; but although some was undoubtedly carried away, the ice seems to have swept across the clays without cutting into them very much.

South and east of the dotted line on the map, already alluded to, boulders are almost entirely absent, being chiefly found in the beds of brooks, where they have been carried by water since glacial times, and are never very large.

Modified Drift, or material derived from the glacier, but more or less sorted and stratified by water, may be seen on the plains lying east of the moraine from near Gifford's to Clifton. The soil over this area is seen in well-diggings to be imperfectly stratified, and to consist of loam and sand, with few pebbles and fewer boulders.

On Todt Hill, near the moraine, there is quite an extensive deposit of gravel, colored yellow by oxide of iron, which may perhaps be referred to this formation; and deposits of sand, without clay, gravel or boulders, may be seen in a few places within the morainal area.

Occasionally some stratification may be seen in the morainal hills themselves, but these are generally very heterogeneous in composition. Modified drift also occurs in small quantities along the edge of the moraine near Tottenville. The true glacial drift is not thick in this vicinity, generally forming a mere mantle over the Cretaceous strata, and was probably deposited by a local projection of ice in advance of the main glacier.

Limonite Iron Ore.—The era of the formation of these deposits is only provisionally referred to the Quaternary. It is impossible to say how early their deposition began, but it was

probably long before the glacial epoch; we are only sure that they are more modern than the magnesian rocks which they rest upon, and older than the glacial drift, which overlies them in some places.

These beds of iron ore are found resting directly upon the serpentine or talcose rocks at a number of places; and where mining has been carried on, the localities are indicated on the map. All the deposits have the same general characteristics,—they are superficial, although sometimes covered by glacial drift to a variable depth. The ore consists of the hydrated sesquioxide of iron, Limonite, and is either compact or quite earthy in texture. All that I have examined gave a yellowish-brown streak; it is possible that there is some Hematite occurring with it, but I have never seen any ore from Staten Island which would give a red streak. The Limonite is associated with colorless, green, and red quartz; it has been extensively mined near Four Corners, at several places on Todt Hill and Richmond Terrace, and along the Clove Road, and is known to occur at other places on the serpentine hills.

The following analyses have been kindly furnished me by Mr. D. J. Tysen, Jr., who is interested in the mining industry.

(1) Ore from Todt Hill—

	Fe_2O_3	67.50 per cent.
	MgO	1.90
	CaO	1.46
	Al_2O_3	5.82
	P	0.046
	Mn	1.619
	SiO_2	10.80
	H_2O	7.73
	Cr	3.00
Metallic iron,	- -	47.25 per cent.

The amount of Chromium is probably too high.

(2) Ore from near Four Corners—

		(A)	(B)
(A)	Fe_2O_3	79.27	(B) 76.72
	Al_2O_3	1.20	0.96
	Cr_2O_3	1.15	1.60
	Mn_2O_3	0.32	0.64
	SiO_2	5.70	5.52
	CaO	tr.	tr.
	MgO	tr.	tr.
	H_2O	12.39	14.76
	P	tr.	tr.
	S	tr.	——
		100.03	100.20

Metallic iron in (A), 55.49 pr. ct.
" " (B), 53.70 "

These superficial deposits have probably had their origin in the deposition of the material composing them from the waters of thermal springs, which have come to the surface through crevices in the serpentine; the iron in the solutions was probably in the form of the carbonate, which on reaching the surface became oxidized by contact with the atmosphere, and was thrown out of solution and deposited as the hydrated sesquioxide, as we now find it. Magnetic iron sand occurs with the Limonite in one of the deposits on Todt Hill; this was probably washed in mechanically while the hydrated oxide was being deposited from solution.

The deposits vary from a few inches up to twelve feet, or even more, in thickness; their lateral extent is limited to a few hundred feet in any direction. The Todt Hill mines are the only ones wholly uncovered by glacial drift, being east of the moraine.

Æolian or Blown Sand.—Extensive deposits of light-colored sand, similar in character to those found so abundantly on Bergen Neck, N. J., occur along the edges of the salt meadows on the western side of the Island, from Mariners' Harbor to near Chelsea Landing, sometimes extending to a distance of one-half

or three-quarters of a mile on the upland, and thus occupying a position between the trap-dyke and the salt meadows. The material is a fine, yellowish, loamy sand, containing no gravel or pebbles, but rests on the glacial drift, and is hence of post-glacial age. This sand was once the western beach of the extensive body of salt water which formerly occupied the basin now filled with the salt-marsh deposits, and which extended over all the Newark and Hackensack Meadows, but has now been reduced to the area of Newark Bay. The sands of this old beach were blown inland, and formed into dunes by the generally prevailing westerly winds; on a windy day the manner of the formation of these dunes may still be plainly seen. A number of pine-barren plants have found lodging in this sandy soil, on both Staten Island and Bergen Neck, and it is probable that others will be found there on further exploration.

Modern Epoch.

Under this heading are included deposits whose formation began at a comparatively recent period, and whose growth still continues.

Marine Alluvium or Salt Meadows.—These deposits extend over an area of about nine and one-half square miles on Staten Island. The material composing them consists for the most part of partially decomposed vegetable matter, mixed with a little clay and sand. These salt-meadow areas have formerly been shallow bays, which have gradually been filled up, first by the deposit of silt from their waters and the growth of marine plants, and ultimately by the growth and decay of grasses and rushes. This latter process is yet in operation, and thus the salt meadows keep at about the level of the highest tides; their most abundant grass is the *Spartina juncea*, Willd., while the rush is *Juncus Gerardi*, Lam., commonly known as "black grass." A number of other plants contribute small amounts to the vegetable growth, making the salt-meadow flora quite a varied one.

The most extensive areas covered by these deposits are along New Creek and the Great Kills, on the eastern shore, and from

Rossville northward along Arthur Kill. The thickness of the marshes is exceedingly variable, probably as much as thirty feet in some places, and but a few inches in others. The dried material consists of decaying fibres, mixed with a little clay, sand, and oxide of iron; the latter substance produces the iridescent film commonly seen in the marshes, and popularly supposed to be oil.

Sand Beaches and Points.—Sand beaches occur along all the shores that are directly exposed to the waves; the greatest accumulation of sand is on the shore of the Lower Bay from Clifton southward to the so-called Point of the Beach, near Gifford's, at Seguine's Point, near Prince's Bay, and at Ward's Point, Tottenville. The point near Gifford's is slowly lengthening and curving in toward the shore; a similar point is in process of formation at the mouth of New Creek; and the accumulation of sand at Ward's Point is quite great. These points are produced by the combined action of the currents of the Lower Bay and the streams flowing into it, which carry the sand along the coast until finally it is driven up on the beaches by the waves.

Sands composed of magnetic iron ore occur with the quartz sand, and are generally found in layers of a fraction of an inch in thickness; but an accumulation of this material to a depth of four inches has recently been found at low water on the beach near the Elm Tree Lighthouse, and has excited some attention as a possible iron ore, but it contains titanium, and is not likely to have any economic importance. All the sands have originally resulted from the disintegration of rocks, and have been carried by water down the rivers emptying into the bays, and also resulted in part from the direct disintegration of the coasts.

Peat Swamps.—True peat occurs in but few places on Staten Island. Some is found in the Clove Lake Swamps, in several swamps near Richmond and Gifford's, and towards Tottenville. In one locality near Richmond, the peat deposit is at least ten feet thick. The salt-marsh deposits may be regarded as a kind of peat, but their vegetable matter comes principally from

grasses and rushes, while true peat results from the growth and decomposition of mosses.

Encroachment of the Lower Bay.—The entire southeastern shore of Staten Island is gradually being washed away, and hence receding to the westward. In some places the loss is very apparent. At the foot of New Dorp Lane, near where the Elm Tree Lighthouse is now situated, a large American elm was standing not longer ago than the year 1840. The place where this tree grew is now beyond the end of a dock which extends some four hundred feet from the shore. This indicates a loss of four hundred feet in forty years, or an average of ten feet per year. At Cedar Grove, half a mile south of this point, there has been a loss of about three hundred and thirty feet since 1850, or about the same average. At Prince's Bay, the Government has been obliged to build a heavy sea-wall in front of the bluff on which the lighthouse is placed,—and a like precaution has been taken at the forts on the Narrows.

Now there are two causes operating to effect these results; they are (1) the constant abrading action of the waves and currents, and (2) the gradual depression of the coasts. From the course of the currents in the Lower Bay, the eroded material, together with part of that brought down by the rivers, is carried southwardly along this coast, the sands deposited as beaches, bars and points, while the finer muddy part is carried farther, and finally deposited in the deeper waters of the Bay or in the ocean.

It has been the custom to save property from this very serious loss by building bulkheads filled with stone, some hundreds of feet outward from the shore at the southern end of the land to be protected. These bulkheads act to break the force of the sand-bearing current flowing along the shore; and this check to to the motion of the water, causes it to deposit its burden on the north side of the dock. The waves soon drive the sand up on shore, and land is actually made in this manner. It is probably the cheapest and most effective way of protecting property on this coast.

The second cause which is in operation, and which, although very much slower, is perhaps surer to submerge much valuable

land, is the gradual sinking of the coast. Prof. George H. Cook has estimated the depression of the shores of New Jersey and Long Island at about two feet per century; others have thought it somewhat less, but all are agreed that there is a subsidence going on. It will be seen that if our coast settles down to ten feet below its present level, the greater part of the plains extending south of the moraine from Giffords to Clifton, now the most valuable farming land in the county, will be covered with salt meadows within a few hundred years, provided that they are not all washed away before by the action of the currents. For a full discussion of this subject see Geology of New Jersey, 1868, pp. 343–374.

Economic Geology.

(1) *Iron Ore.*—The Limonite ore of Todt Hill, Four Corners, and other places, has been used in blast furnaces in connection with other more refractory ores, or has been screened, ground and washed, to produce red ochre paint. The total amount hitherto mined may be as great as 250,000 tons, and the present production is about 20,000 tons per year.

(2) *Fire Clay.*—The character of the deposits of this substance has already been described. Messrs. Kreischer and Sons have a large factory at Kreischerville, and produce refractory ware valued at over $50,000 annually. Their supply of clay is partially drawn from Woodbridge, N. J.

(3) *Brick Clay.*—Clays of glacial drift origin are used in the manufacture of common brick near Richmond and Linoleumville. The number of bricks annually produced has not been definitely ascertained, but it probably amounts to several millions.

(4) *Trap Rock.*—Quarries of this rock have been worked at Graniteville and near Port Richmond for many years. The rock is either cut into blocks and shipped to New York to be used for street pavements, or crushed into small pieces and employed in MacAdam or Telford pavements on Staten Island. Some edifices have been constructed of this rock, but it is not well suited for building purposes.

(5) *Serpentine Rock.*—The compact variety has not yet been used for any economic purpose; it is too soft and weak to be used for building; it might be employed in the manufacture of magnesian salts, or for some purposes where refractory materials are required.

The fibrous serpentine, erroneously called asbestos, has been mined near Tompkinsville Landing to the extent of 25 or 30 tons, and used for the purposes for which asbestos is employed.

(6) *Beach Sands.*—Thousands of tons of this material are annually taken from the southeastern coast, and used in New York and Brooklyn for building. In some places so much sand has been removed that property along the shore has been seriously damaged, by exposing roads and meadows to the action of the waves.

(7) *Peat* has never been used as a fuel to any extent on Staten Island, and has little economic value.

(8) *Gravel* occurs extensively along the beaches, and at the locality already noted on Todt Hill. It is valuable as a road-making material, where only light traffic is employed.

Archæology.

Implements used by the aborigines have been found abundantly on the sands of the Cretaceous near Tottenville, in association with scattered oyster-shells. These Indians are supposed to have belonged to the Delaware nation; they visited the sea-coast at certain seasons, and oysters appear to have been a prominent article of food with them. These shell-heaps are found much more extensively on the sand-hills between South Amboy and Keyport, New Jersey, and hence most of the Indians are supposed to have remained there, while a few crossed to Staten Island. The stone implements have also been found at other places in the county, but nowhere so abundantly as at Tottenville. Mr. W. S. Page, of that place, has a collection of 4 stone hammers, 2 pestles, 5 spear-heads, 15 arrow-heads and 12 flint chips,—nearly all picked up in his garden. Others have found similar implements in the same neighborhood. Mr. Arthur Hollick, of Port Richmond, has two stone hammers, three spear-heads, and seven arrow-heads, found in various parts of the county.

EXPLANATION OF PLATE XIV.

———o———

Each figure (except 1*b*) is represented the natural size of a medium specimen.

FIG. 1.—*Spirifer lœvis*, Hall. 1. Ventral valve, viewed perpendicularly to the plane of the margins. *a.* A patch of surface-markings. 1*b.* A portion of the margin of a large specimen, showing the rudimentary plications, extending only a short distance from the margin.

FIG. 2.—*Sp. lœvis*, H. *a.* Hinge-area, deltidium, and beak, of the ventral valve. *b.* Dorsal valve, detached and lowered so as to expose the area of the ventral valve above its cardinal margin.

FIG. 3.—*Sp. fimbriatus*, Conrad. Ventral valve, viewed perpendicularly to the plane of the margins. The dotted line on the left represents the outline of the extreme of a common direction of variation.

FIG. 4.—*Sp. fimbriatus*, C. *a.* Beak and area of ventral valve, detached and the beak tilted toward the observer, giving direct view of the area. *b.* Perpendicular view of dorsal valve.

FIG. 5.—*Sp. lœvis*, H. Side view. In general effect this is a restoration, made upon examination of a great number of distorted and imperfect specimens.

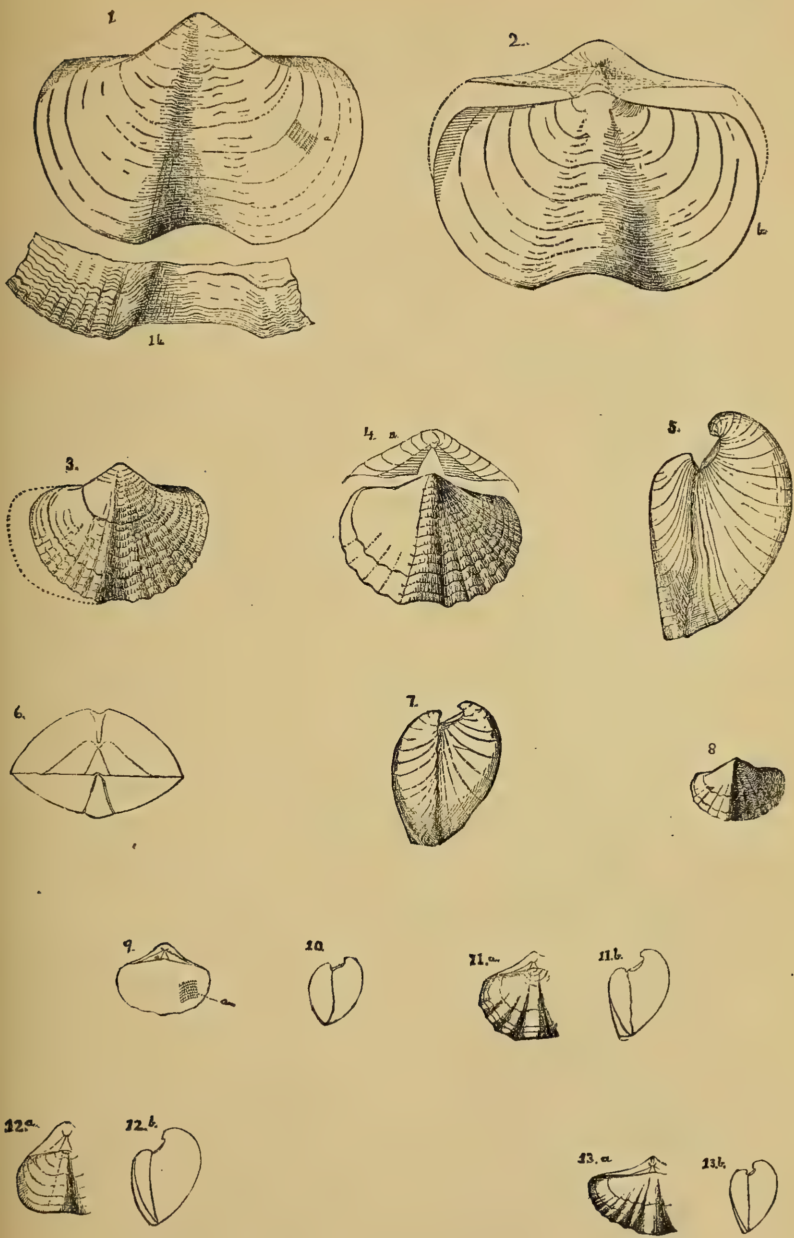
FIGS. 6 and 7.—*Sp. fimbriatus*, C. Cardinal and side views.

FIGS. 8, 9 and 10. *Sp. crispus*, Hisinger. Ventral, dorsal and side views of a medium specimen. This is a reproduction of Hall's original figures, 3*b* and 3*c* of Pl. 54, Vol. 2, Pal. of N. Y. The hinge-area is, however, more produced than appears in speeimens examined by the author. *a*, on Fig. 9, is a small patch, slightly enlarged, of the surface-markings

FIGS. 11*a* and 11*b*.—Variety of *Sp. crispus*, showing the shortening of hinge-line and area, greater elevation of beak, and lessening of plications.

FIGS. 12*a* and *b*.—*Sp. bicostatus*, Vanuxem.—A copy of Hall's Fig. 4, Pl. 54, l. c., regarded as the extreme variety of the *crispus* type in the direction in which Fig. 11 is intermediate ; the plications are obsolete, the area and beak high, the inequality in the relative convexity of the valves extreme.

FIGS. 13*a* and *b*.—*Sp. crispus*, His. Extreme variety in the opposite direction, toward *Sp. sulcatus*, in which are conspicuous the extended hinge-line, small and low beak, low but still short area, distinct and more numerous plications.


1
2.
a
b
1b
3.
4. a
5.
6.
7.
8
9.
a
10
11.a
11.b
12.a
12.b
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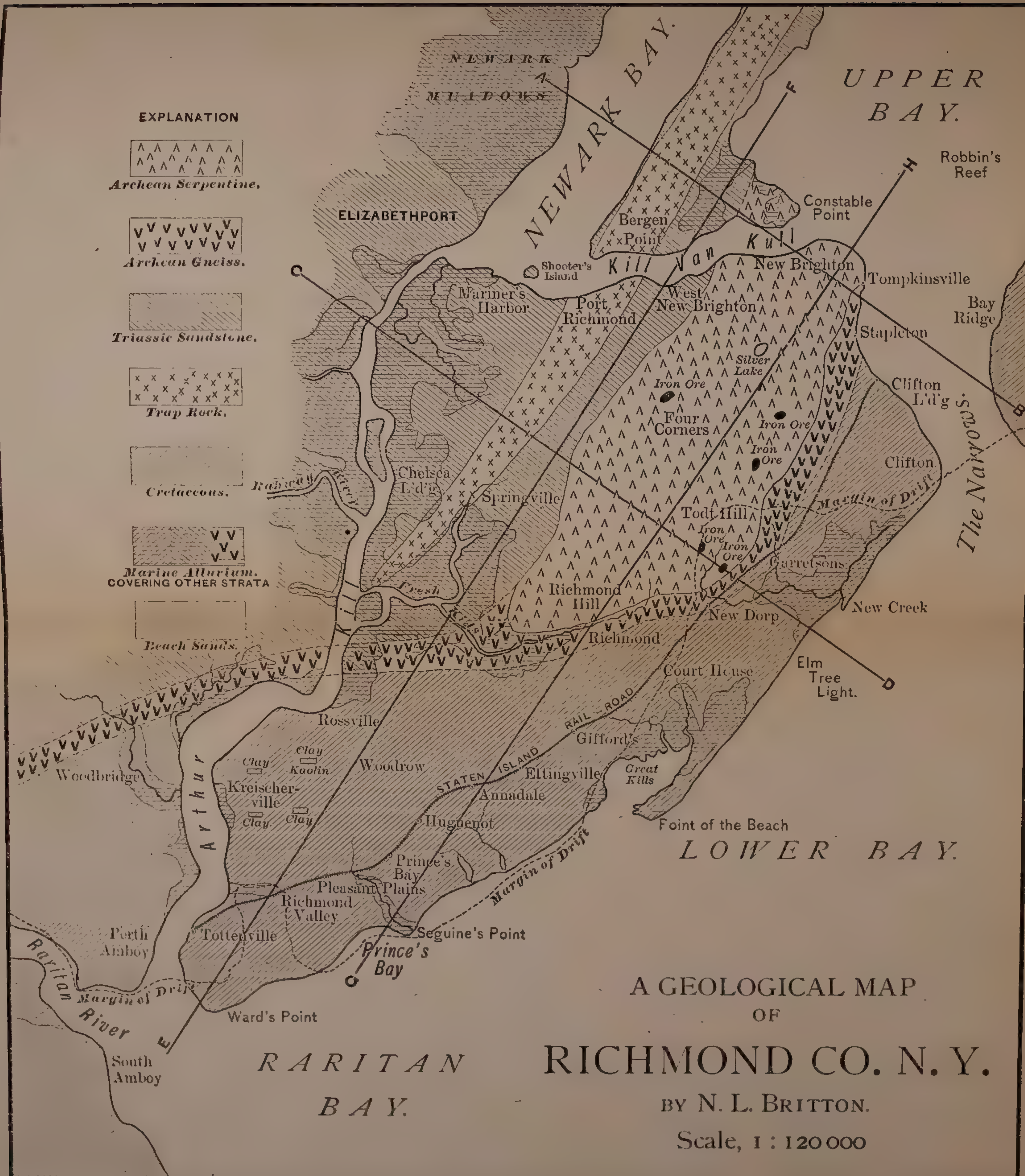

A GEOLOGICAL MAP OF RICHMOND CO. N. Y. BY N. L. BRITTON. Scale, 1 : 120000

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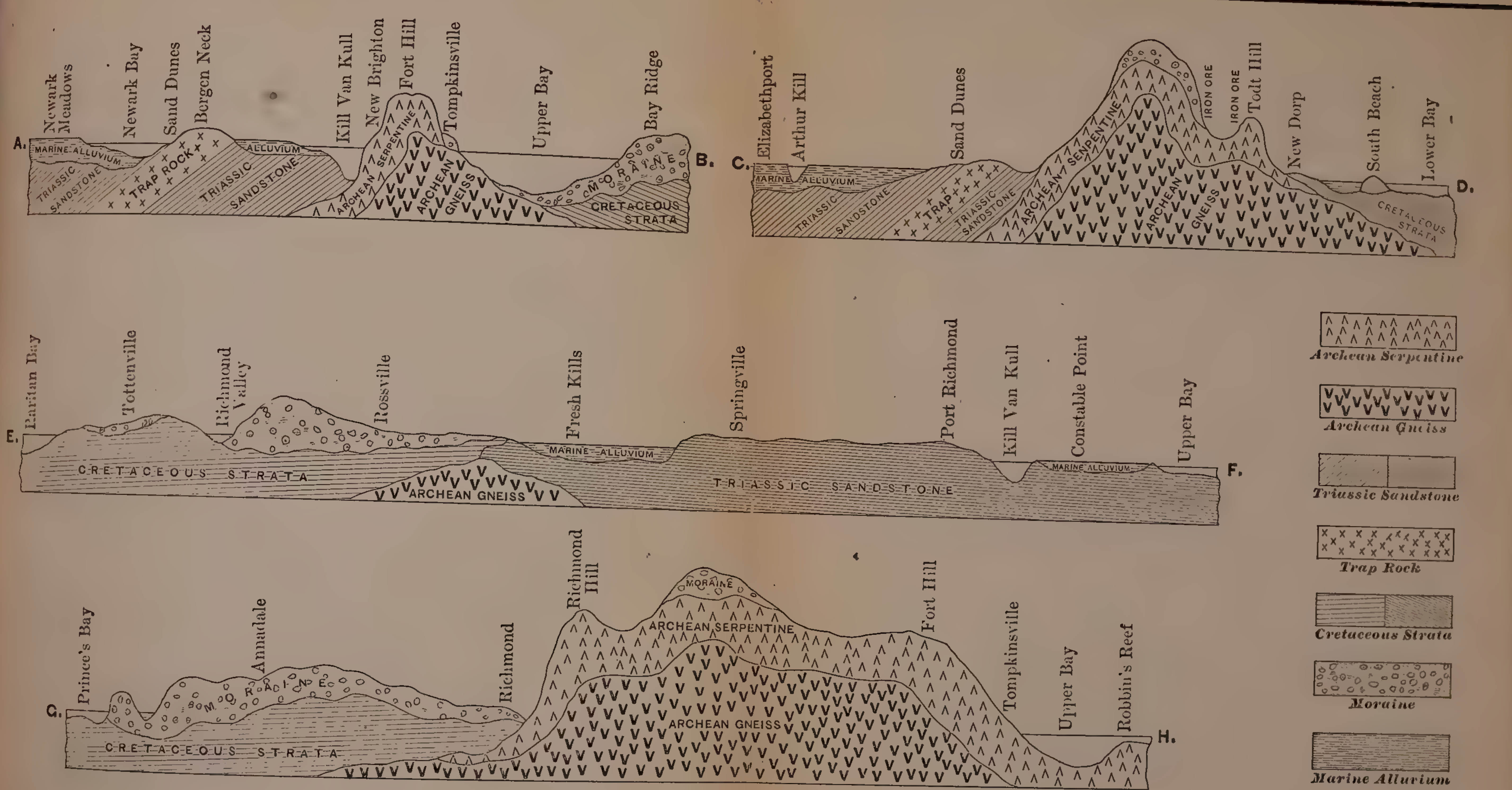

GEOLOGICAL SECTIONS ACROSS STATEN ISLAND.
BY N. L. BRITTON.

RUSSELL & STRUTHERS, ENG'S, N. YORK.

ANNALS

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XII.—*Outline of the Geology of the Northeastern West India Islands.*

BY P. T. CLEVE,

OF THE UNIVERSITY OF UPSALA, SWEDEN; CORRESPONDING MEMBER, N. Y. A. S.

Read November 7th, 1881.

In the winter of 1868–69 I made a geological survey of the northeastern corner of the West Indian Archipelago. The results obtained were published in the Transactions of the Royal Swedish Academy of Sciences of Stockholm (T. IX, No. 12, 1871), with some geological maps of the islands surveyed. Considering that the many details, which are gathered in this paper, may prevent the reader from getting a clear idea of the geology of this interesting part of the globe, and that the paper may not be easily accessible to American readers, I have acceded to the wishes of my respected friend, Mr. Thomas Bland, and written a short outline of the most important facts found by myself, and compared them with observations made by other geologists in other parts of the West Indies.

The geological ages in which the material forming the islands was deposited, or protruded from the interior, are the *Cretaceous*, the *Eocene*, the *Miocene*, *Pliocene* and *Post-pliocene*.

THE CRETACEOUS FORMATION forms the whole of the archipelago of the Virgin Islands except Anegada, which may be referred, as also the Bahamas, to the Post-pliocene time. Also the island of Vieque, near Porto Rico, seems to consist for the most part of eruptive Cretaceous rocks. Still, there seem to be also in this island younger strata; but I cannot say anything with confidence about this, having paid only a short visit on this island.

A map of the Virgin Group shows a series of larger islands and smaller keys, extending generally east and west. The larger are Culebra, St. Thomas, St. John, Tortola and Virgin Gorda. Their general direction coincides with the strike of the strata, wherever such is visible. South of these, but at some dis-

tance, is the island of St. Croix, also with an east and west direction.

The rocks composing the Virgin Island range are of very different kinds, massive eruptives, without stratification, enormous masses of clastic volcanic rocks of most variable kinds, regularly stratified metamorphic slates, siliceous limestones, metamorphic limestone, etc., very often penetrated by black trappean dikes, in the most astonishing manner resembling the trap-rocks which abound in the old rocks of Scandinavia.

The VOLCANIC ROCKS are principally the following:

1. *Diorite,* closely resembling syenite, is of great extent in the island of Vieque; it occurs in a small key (Buck's Island) south of St. Thomas, and farther in the southern peninsula of Virgin Gorda, whence it may be traced in smaller patches around the shores of Sir Francis Drake's Channel to the northern point of St. John. This massive, granite-like rock consists of hornblende and soda-lime feldspar, with very little mica. I could not find quartz in it. It is easily altered, and shows then its interior globular or concretionary structure. The small island south of Virgin Gorda, called *Broken Jerusalem*, consists entirely of large boulders of hard diorite, left after the softer mass between has been carried away by decomposition, and is a beautiful illustration of the globular structure of the rock. On the small keys south of Drake's Channel, the massive structure graduates into one more or less stratified, so that in some places distinct remains of strata are visible. In other places the main mass sends forth branching veins into the surrounding rocks, proving that it once was in a molten state.

The facility with which the rocks disintegrate and decompose, makes it very probable that a mass of the diorite once filled the whole space now occupied by Sir Francis Drake's Channel, but has been carried away by alteration or denudation.

2. *Felsite.*—This rock, which also could be classed as eurite, or in some spots as quartz-porphyry, forms the southern part of St. Thomas, St. John, and Peter's Island. It is visible also on the northern part of Virgin Gorda. The color is generally light, whitish, reddish, sometimes by alteration blood-red. It is

a compact mixture of quartz and feldspar. In some places the quartz is separated in the form of double pyramids. The rock is evidently, in most places, a clastic rock, a kind of tufa; in others, it seems to have been protruded in a molten state as a lava. In the latter case, it has sometimes a fine columnar structure, as at Red Point on St. Thomas.

3. *Blue-beach.*—This rock, so called by the inhabitants, is a peculiar kind of breccia of fragments of felsitic or trappean rocks, evidently a clastic volcanic rock. The color is generally very dark green, from a considerable quantity of hornblende, often altered to chlorite. In this rock, distinct traces of stratification are often visible. The dip of the beds is generally very steep, almost vertical. This rock constitutes the greater part of St. Thomas, St. John, Tortola, and Jost Van Dyck.

4, *Diabase.*—Occurs in dikes penetrating the diorite and the blue-beach. Sometimes it occurs in greater masses, as in the island of Hans Lollick, north of St. Thomas. The island of Culebra consists of a kind of diabase, or, more correctly, of Labrador porphyry.

All these igneous beds are of enormous thickness, and point to a long period of very powerful volcanic activity. They are of two different types, just as in modern volcanoes; more basic, black rocks,—traps, diorite and their tufas (or blue-beach), and more acidic,—white or light colored, the felsites with their tufas. The latter seem, also, older than the former.

The Stratified, generally Metamorphic Rocks, have comparatively small extent; many of them have doubtless been volcanic ashes, in a state of fine division, deposited on the bottom of the sea. They consist of—

1. *Clay-slate.*—A black slaty rock, without fossils, closely resembling the slates of the Silurian formation. It occurs in the northern part of St. Thomas, near Coki Point, and on southwestern Tortola, near Cox Head. The strata are almost vertical, and run from west to east.

2. *Metamorphic slates.*—Mica schist, hornblende schist, etc., occur on the small keys south of Francis Drake's Channel, and on the islets between Tortola and St. Thomas.

3. *Limestone.*—Hard, crystalline, bluish-gray marble, occurs on Congo Key and on Great Patch Island, near St. John; also on Mary's Point, on the latter island, and in some other places. Sometimes the lime is so strongly impregnated with silica that it forms a peculiar, still stratified rock,—*siliceous limestone,*—which is filled with garnet, epidote and other silicates. Near Coki Point of St. Thomas, the limestone stratum thins out in small rounded lime boulders, which occur imbedded in the blue-beach rock. These rolled pieces contain fossils, sometimes silicified and well preserved, which allowed me to make out with certainty the geological age of the Virgin Islands.

The Island of St. Croix consists in its northern part of clay-slates, blue-beach, felsitic rocks, and some limestone, all of the same character as in the Virgin Islands, dipping at very high angles, often almost vertical, and running, though with many deviations, from west to east. South of this rocky part of the island, extends a wide level area of coral limestone and marls, probably of Miocene or perhaps more recent date.

Fossils of the Cretaceous Formation.—The fossils collected near Coki Point, on St. Thomas, were abundant fragments of a large *Nerinæa, Actæonella, Pectunculus, Astarte, Corbula, Limopsis, Opis,* and one *Ammonite.* All these fossils prove the age to be Cretaceous, and probably corresponding to the Gosau formation in the Alps.

The Cretaceous formation of the Virgin Islands and St. Croix consists, then, chiefly of volcanic rocks, often stratified and associated with large eruptive masses of a light colored diorite, closely resembling syenite. Their strike is generally east to west, and their dip very strong, which proves that they have been elevated and bent by a great pressure, acting from north or south at a right angle to the strike of the strata. On studying in detail the part between Tortola, St. John and St. Thomas, I found that there is a synclinal fault just in the continuation of Sir Francis Drake's Channel. Tortola and St. John, with its continuation, St. Thomas, are only parts of the same large set of strata, as will be clear by the accompanying schematic section (Plate XVII).

There is little doubt that St. Croix, also, is the continuation of the same beds, although the depth between the Virgin Islands and St. Thomas is enormous, about 4,000 meters. The Virgin Islands and St. Croix are then to be regarded as the lofty summits of a submarine Alpine parallel chain. The time at which this chain began to be formed, or when the pressure from north or south commenced to work, is certainly after the period when the Turonian strata were deposited, probably in the time of the white chalk; and there is evidence that the forces were still acting after the Eocene time, as will be seen further on. In the Miocene time the chain was finished, and ready for the deposit of the almost horizontal and little-disturbed Miocene limestones.

The island of Porto Rico consists largely of very thick, almost undisturbed limestone beds of Miocene age; but in the interior of the country, around Utuado, rocks similar to the Cretaceous of the Virgin Islands, are met with. The same geological structure will be found in Jamaica, near Bath, and in the Clarendon District, as Mr. Barrett has stated. In San Domingo, too, the Cretaceous beds, with associated syenite-like eruptive rocks, are of great extent.* In Cuba, also, they seem to be present. Everywhere the strata are strongly tilted, disturbed, raised, and highly metamorphosed.

The large West Indian islands contain, then, ridges of raised Cretaceous rocks, and the Virgin Islands form their eastern outcrops. South of the Virgin Islands, they are not met with, except in Trinidad, where they form the "older Parian" formation of Mr. Wall. It may be regarded as uncertain whether the strata of Scotland, in the Island of Barbadoes, belong to the Cretaceous or Eöcene formation.

Eocene Formation.—East of the Virgin Group are the two islands of St. Martin and St. Bartholomew, which belong to the Eocene time. St. Bartholomew consists of a thick set of clastic

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* See *Gabb*, on the Topography and Geology of Santo Domingo. Transactions of the American Philosophical Society of Philadelphia, XV, Part I, 1873.

volcanic rocks, tufas of different kinds, interstratified with beds of a hard, compact limestone. There are also some massive rocks, certainly eruptive, consisting of a kind of syenite-porphyry, in the southern part of the island. St. Martin, also, consists mainly of stratified rocks, but not of limestone, as far as I know. The stratification runs generally, both in St. Martin and St. Bartholomew, from west to east, and the dip is to the south about 20°—30°. As most of the rocks are of volcanic origin, we may conclude that the igneous activity continued during the Eocene time.

On the western corner of St. Martin, the Eocene strata are unconformably overlaid by hard white limestone, evidently a fragment of the Miocene formation, which forms the whole of Anguilla, and there rests upon some amygdaloid volcanic rock.

The Eocene rocks seem to occur in the southwestern part of Antigua,* where they have a northerly dip ; also, in Guadeloupe, Grande-Terre, they seem to occur (Pierre à Ravets de Duchassaing). In Jamaica, Eocene beds of 1,000 meters in thickness occur, and consist, according to Mr. Barrett, of porphyritic conglomerates, with shaly and sandy beds. Mr. Gabb does not mention the occurrence of Eocene beds in San Domingo. They will probably be found there, however, and have perhaps been considered as parts of the Cretaceous or of the lower Miocene formations.

Fossils.—The limestone of St. Bartholomew is rich in fossils, but generally in a bad state of preservation. Also in Trinidad Eocene fossils have been found. The age of St. Bartholomew is, beyond any doubt, that of the Calcaire Grossier of Paris. There occur a large *Cerithium,* identical with or nearly allied to *C. giganteum,* a large *Nerita* allied to *N. conoidea,* and several species of *Voluta, Rostellaria, Phorus, Cypræa, Natica,* etc. My collections of fossil mollusks were sent ten years ago to Prof. Carl Mayer, of Zürich, for determination ; but he has not yet

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* See *Nugent,* Descr. of Antigua ; Trans. London Geol. Soc., 1st Ser., Vol. V, p. 459, 1841.

Howey, Geology of Antigua, Am. J. Sci., XXXV, p. 75, 1839.

Duncan, Quart. J. G. S., XIX, p. 408, 1863.

finished the examination. Very abundant is the *Terebratula carneoides*, Guppy, also occurring in Trinidad. Another species of brachiopod, *Argiope Clevei*, Davidson, was also found on St. Bartholomew. The corals are numerous, and have been described by Mr. P. M. Duncan (Quart. Jour. G. Soc., XXIX, pp. 518—565). The echinoderms have been described by M. Cotteau (Description des échinîdes tertiaires des Isles St. Barthelémy et Anguilla) in K. Sv. Vetenskaps Akademien Handlinger, T. XIII, No. 6, 1875. The foraminifera are very numerous, but have not been examined. Fragments of crabs, *Ranina*, occur also in St. Bartholomew.

As the Eocene strata are inclined, and their strike is generally east and west, there is evidence that the force which pushed the Cretaceous strata into such gigantic folds, was still active after the Eocene time, but not with such great intensity as before, because the Eocene strata are not more inclined than 20°—30°, while the Cretaceous in many places are almost vertical. These facts indicate that the rising of the mountain chains in the great Antilles took place in the epoch between the Turonian time and the Miocene.

Miocene Formation.—Among the small islands of the northeastern part of the West Indies, the Miocene formation occurs in Anguilla, where it has been deposited on a kind of volcanic amygdaloid rock, visible on the northern coast. It consists of limestone and marls (sometimes very rich in fossils, which generally are in the form of casts), covered by a hard limestone bed, which slowly dips down to the south. The same limestone bed occurs in the western point of St. Martin, directly and unconformably deposited on the Eocene formation.

Miocene beds have also been found in Antigua, Barbadoes and Trinidad. Grande-Terre of Guadeloupe seems to consist principally of Miocene strata. The level land of St. Croix is probably Miocene, but complete evidence of this is still wanting.

In the large West India islands, Jamaica, Porto Rico, San Domingo and Cuba, the Miocene formation has an enormous development. It consists largely of limestones, generally almost horizontal or very little inclined,—evidence enough that the mountain-chains were completed before the Miocene epoch,

that they were largely submerged in the Miocene time, and that after this period a continental uplift occurred in the West Indies.

PLIOCENE AND POST-PLIOCENE FORMATIONS.—The line of separation between the Miocene and Pliocene formations in the West Indies is nowhere decided. It is possible that the hard, yellowish-white limestone, which contains only few fossils and covers the true Miocene beds, may be more accurately called Pliocene, and not Miocene, as I have done in the foregoing. On the other hand, it is by no means easy to draw a line of demarcation between the Pliocene and Post-pliocene time. I am inclined to think that the island of Sombrero is of Pliocene origin, also Barbuda and some part of Barbadoes.

To the Post-pliocene time are to be referred the very important volcanic formations which extend from Saba through St. Eustatius, St. Kitts, Nevis, Redonda, Montserrat, Guadeloupe, etc. In St. Kitts I found, near Brimstone Hill, a white limestone formation, containing a large number of fossils, generally impressions and casts. All the specimens, belonging to about forty-three different species, could be identified with living Caribbean species, except only a single specimen of *Modiolaria*. It is not improbable that the elevation of the Miocene strata was accompanied by a subsidence in the Caribbean sea, and that on the limit between the area of elevation and that of subsidence, large fissures originated, pouring out the tufas and other igneous products, of which the volcanic islands are formed.

To the Post-pliocene time may also be referred a limestone formation of great extent, forming the island of Anegada, and the Bahamas. Anegada is a flat, very low island of limestone, containing great numbers of fossil shells belonging to species still living in the Caribbean sea. Anegada is nearly allied, in its geological structure, to the Bahamas, and proves that in this part of the Caribbean area an elevation and not a subsidence is going on.

DESCRIPTION OF PLATE XVII.

FIGURE 1.

Section from St. John to Jost Van Dyck (Virgin Islands).

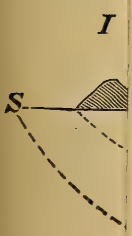
1,	1,	St. John.
2,	2,	St. Thomas.
3,		Great Thatch Island.
4,		Jost Van Dyck.
5,		Tortola.
6,		Tobago.
7,		Iguana ("Guana") Island.
	a,	Coki Point, St. Thomas.
	b,	Mary's Point, St. John.
F,		Felsite.
B,		"Blue-beach."
M,		Metamorphic rocks.
L,		Limestone.
D,		Diorite.

The dotted lines indicate islands not on the precise line of section.

FIGURE 2.

Sections from St. Croix to Tortola, and from Nevis and Antigua to Anguilla.

I,	Antigua.	
II,	Nevis.	Post-pliocene volcanoes.
III,	St. Kitts.	Post-pliocene volcanoes.
IV,	St. Eustache.	Post-pliocene volcanoes.
V,	Saba,	Post-pliocene volcanoes.
VI,	St. Croix.	
VII,	St. Bartholomew.	
VIII,	St. Martin.	
IX,	Anguilla.	
X,	St. John.	
XI,	Tortola.	
XII,	Anegada.	
C,	Cretaceous.	
E,	Eocene.	
M,	Miocene (and Pliocene).	
P P,	Post-pliocene.	



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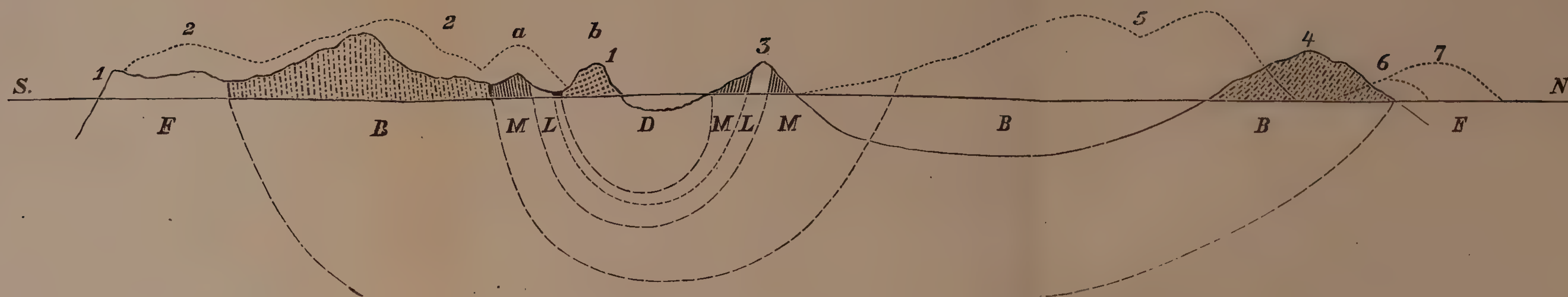
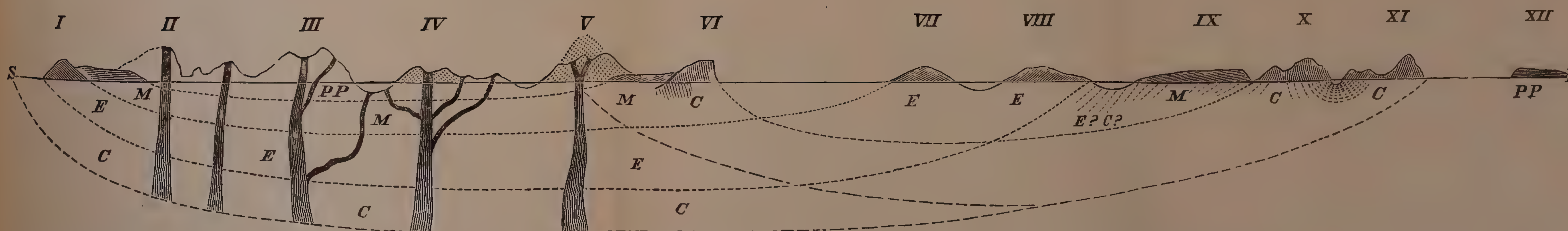


Fig. 1. Section through the Virgin Islands, from St. John to Jost Van Dyck.



Drawn by P. T. Cleve.

Fig. 2. Sections through the Leeward Islands, from St. Croix to Tortola, and from Nevis and Antigua to Anguilla.

Eng. by B. B. Chamberlin.

XIII.—*Descriptions of New Species of Fossils from Ohio, with Remarks on some of the Geological Formations in which they occur.**

BY R. P. WHITFIELD.

Read January 16th, 1882.

Species from the Hydraulic Limestones of the Lower Helderberg Group.

BRACHIOPODA.

Streptorhynchus hydraulicum, n. sp.

Pal. Ohio, Vol. III, Plate 1, Figs. 1—3.

Shell small to minute, the largest individuals yet observed not exceeding five-eighths of an inch in greatest diameter, while the most of those observed are not more than two-thirds as great. Valves depressed convex, or, more commonly, appearing very flat, as seen on the surface of the stone. Hinge-line straight, nearly as long as the width of the shell below, and the latter usually more than the length, frequently nearly once and a half as great. Ventral valve characterized by a very narrow and nearly vertical cardinal area, and a usually more or less twisted or otherwise distorted beak. Dorsal valve slightly more convex than the ventral, with a perceptible mesial depression extending from beak to base, becoming broad and undefined below the middle of the length. Surface of the shell marked by coarse and somewhat ridged radiating striæ, which are distinctly alternating in size ; the principal ones proportionally very strong.

The small size of the shell, with the strong radiating and alternate striæ, are distinguishing features of the species. There is no species resembling it, to any degree, among the fossils of New York rocks of a corresponding age. It presents much more the features of forms of the genus from the Coal measures than any heretofore described from Silurian rocks of America, and will not be readily confounded with any known species.

Formation and Locality.—In the hydraulic beds of the Lower Helderberg group, at Belleville, Sandusky County, and at Green-

* These descriptions will be reprinted in the forthcoming Volume of the Palæontology of Ohio, and will be accompanied by Illustrations, to which the references by Plate and Figure, given in the present article, under each species, relate.

field, Ohio; associated with *Meristella bella*, *Nucleospira rotundata* and *Leperditia alta*, occurring sometimes in great numbers, almost covering the surfaces of slabs.

Nucleospira rotundata, n. sp.

Pal. O., III, Plate I, Figs. 11—14.

Shell attaining a rather large size for the genus, being often more than half an inch in transverse diameter, and when of medium or large size, strongly ventricose or rotund. The younger individuals, however, are depressed-convex or lenticular in profile. Length of the shell as great or greater than the transverse diameter. Beaks small and incurved, not at all conspicuous. Valves marked by a slight depression along the median line, strongest on the ventral side.

This species, like all those of this formation yet obtained in Ohio, are mostly internal casts and impressions; consequently the true features of the shell are not readily obtained. The general features of the species, however, are preserved sufficiently for identification and comparison, when good individuals are selected. The shell bears much resemblance to *N. ventricosa*, Con., from the Lower Helderberg group of New York, in its general form, except the much greater size and more elongated form of the adult individuals. There is more difficulty in separating them satisfactorily from the casts of *Meristella bella*, Hall, with which they are associated. In fact, it is all but impossible to do this with certainty, unless they are in a good state of preservation, as the difference in the form of the muscular imprint of the ventral valve, and the more strongly incurved beaks, are the only features that can be relied upon.

Formation and Locality.—In the hydraulic limestone of the Lower He'derberg group, at Greenfield, Ohio.

Rhynchonella hydraulica, n. sp.

Pal. O., III, Plate 1, Fig. 17.

Shell rather smaller than medium size, transversely oval in outline and ventricose in profile; the dorsal valve being highly convex, and the ventral somewhat depressed convex. Beaks small, not prominent or conspicuous; that of the ventral valve moderately incurved, and the other rather strongly incurved. Surface of the shell marked by from sixteen to eighteen simple plications, four of which are strongly elevated on the front half of the dorsal valve to form the mesial elevation, which does not extend beyond the mid-

dle of the valve, and six or seven may be counted on each side of the valve. The plications are but slightly elevated, are round on the summit, and do not extend beyond the middle of the shell, the upper part of which is smooth, and marked only by concentric lines of growth. The interior of the dorsal valve is marked by a moderately strong mesial septum, extending from the apex of the valve to about one-third of its length. The shell appears to have been also marked by fine concentric lines of growth, some of which form distinct varices.

This species belongs to the semi-plicated group of the genus, of which there are many species having close resemblance to it, but none in rocks of corresponding age or position having very close affinities to it.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Greenfield, Ohio.

Pentamerus pes-ovis, n. sp.

Pal. O., III, Plate 1, Figs. 11—22.

Shell quite small, and of a somewhat broadly triangular form, with depressed convex valves, the ventral side being nearly twice as deep as the dorsal, and more elongated at the beak, giving it the triangular character; cardinal slopes straightened and rapidly diverging; front broadly rounded.' The species is known only in the condition of internal casts, and as thus seen, the ventral valve is deeply cleft along the median line by the removal of the central septum, the slit often extending more than three-fourths of the length of the valve. The filling of the spoon-shaped cavity is proportionally large, being long and narrow, and not strongly arched. Cast of the dorsal valve characterized by a proportionally large and broad cardinal plate, from which project two long and strongly divergent and distant crural processes, reaching far along the surface of the cast in some cases, while in others they are quite short. The surface of the valves has been destitute of plications, but is usually marked in the larger individuals by several strong varices of growth near the front margin, which give to the shell a prematurely old appearance for so small a species; the individuals seldom exceeds five-eighths of an inch in length on the ventral side.

The species is unlike any known form of a similar size, in the shallowness of the valves, in the erect character of the ventral beak, and in the deeply divided feature of the cast of this valve. The dorsal valve is much less marked, and is often destitute of any distinguishing feature.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, in Adams County, Ohio, occurring in

numbers densely packed together, but having the shelly substance entirely removed.

ARTICULATA.

Eurypterus Eriensis, n. sp.

Pal. O., Vol. III, Plate 1, Figs. 31, 32.

Among the fossils from the Hydraulic limestones of Beach Point, Put-in-Bay Island, Lake Erie, there are several detached cephalic shields and one body of a species of *Eurypterus*, which is so distinctly different from any of those described, that it seems necessary to class it as a separate species. The differences, so far as seen on the parts preserved, consist in the form of the cephalic plate, in the size and position of the eye-tubercles, and in the proportions of the body as compared with the known forms. There are undoubtedly other and more important differences in the appendages, but as these are not preserved on any of the individuals examined, comparison is impossible.

The cephalic shield is proportionally broader than that of *E. remipes* or *E. lacustris*, and is more regularly rounded or arched on the anterior border, lacking that subquadrate form characteristic of those species. The eyes are proportionally smaller, and situated nearer each other, and also farther forward, as well as being somewhat more oblique to the longitudinal axis of the body. The minute ocular points are somewhat larger than in *E. remipes*, are situated close together, and are nearly opposite the posterior end of the real eye tubercles; they consist of a pair of distinctly elevated rings surrounding rather deep, although minute, central depressions; the inner margins of the rings being almost in contact. The head does not show evidence of having been margined by an elevated or thickened rim, as in those species, but as the specimens are rather impressions of the inner surface of the external crust than actual external surfaces (being more properly internal casts, the substance of the carapace having been entirely removed), this feature may not be properly shown. The head-plate more closely resembles that of *E. microphthalmus*, Hall (Pal. N. Y., Vol. III, p. 407,* pl. 80 A, fig. 7), from the Tentaculite limestone near Cazenovia, N. Y., than of any other described species; it differs, however,

in being proportionally much shorter, which gives it a more semicircular form. The eye-tubercles are also more nearly of the size of those of that species and similarly situated.

The thorax closely resembles that of *E. remipes* in its general form, but the lower three of four segments are proportionally shorter, giving the posterior extremity a much more compact character. The principal distinction between the two species, as shown by the thorax, exists in a difference of the ornamentation of the surface, as seen on the specimen used. This consists in the minute spine-like pustules or pointed granules, marking the surface of the crust, being arranged in irregular transverse lines across the body, and parallel to the anterior and posterior margins of the segments, instead of being irregularly disposed, as in all other species described. No indication of the longitudinal rows of larger pustules, marking the median line of the thoracic segments, can be traced. Caudal spine not observed.

Leperditia angulifera, n. sp.

Pal. O., Vol. III, Plate 1, Figs. 28—30.

Carapace of medium size, having a length, in adult individuals, of about three-eighths of an inch, by a height of one-fourth of an inch in the broadest part. General form of the outline broadly sub-ovate and widest posteriorly; hinge-line straight, equal in length to two-thirds that of the entire valve; anterior end a little the shortest, narrowly rounding into the broadly curved basal line; posterior end broadly rounded. Surface of the carapace highly elevated and prominent, forming a strong, somewhat angular, longitudinal node just within the basal margin, and near the middle of the length. From this point, the surface slopes somewhat gradually upward to the hinge-line, with a barely perceptible convexity, except on the anterior end, where it is more strongly convex, and characterized by a rather prominent and well-marked ocular tubercle. From the angular node near the lower margin, there is, on well-preserved individuals, a perceptible angulation, extending along the surface to the point of greatest length on the anterior end, and a similar one, but less strongly marked, on the posterior side. There is no perceptible difference in form between the right and left valves, each showing the features about equally developed. No appearance of striations radiating from the ocular tubercle can be detected, either on the internal casts or in the matrices; still the nature of the rock in which they are imbedded is such that very obscure markings would scarcely be preserved.

This species differs from *Leperditia alta*, Conrad, of the same formation, in its larger size, and in the larger and more distinct

eye-tubercle, as well as in its slightly different position; but most distinctly in the sub-angular ridge-like node, and greater convexity of the lower border of the valves. This projecting node being situated near the lower margin, and also being the most prominent point of the valve, causes the rock to adhere to the more abrupt sides when fractured, and gives to the valves as they appear upon the fractured surface a very decidedly triangular aspect, entirely unknown in *L. alta*.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Greenfield, Ohio, where it occurs in great numbers, forming distinct layers through the rock, as does the *L. alta* in the Tentaculite limestone of New York.

Species from the Limestones of the Upper Helderberg Group.

PROTOZOA.

Receptaculites Devonicus, n. sp.

Pal. O., Vol. III, Plate 2, Fig. 10.

A very decidedly marked and characteristic specimen of the genus *Receptaculites,* De France, has been obtained from the limestones of the Upper Helderberg group, by Mr. Ed. Hyatt, of the Ohio State University, from a quarry at Fishinger's mills, about eleven miles north of Columbus, Ohio. The specimen is about two and a half inches in diameter, is broadly concave across the disc, and slightly recurved at the outer margin. The concentric lines of pores or cells are strongly marked, and increase rapidly in size as they recede from the centre of the disc, but the surface has been so much weathered that the grooves left by the removal of the stolons at the foot of the cells are not distinguishable, so that the entire specific characters are not recognized; enough, however, remains to show the general form and proportions. It has much the appearance of specimens of a corresponding size of *R. Oweni,* Hall, from the lead-bearing limestones of the West, both in its general form and in the concavity of the disc, as well as in the proportions and rate of increase of the cell-openings as seen exposed on the surface of the limestone.

The occurrence of a species of this genus at this horizon, is a

rather unexpected feature in its history. The highest horizon of its occurrence hitherto recorded, is in the shaly limestone of the Lower Helderberg group of New York, from which the type of the species *Receptaculites infundibuliformis* (*Coscinium infundibuliformis*, Eaton; Geol. Text-book, 2d Ed., 1833, p. 132, fol. 5, figs. 64, 65) was derived. The figure and description, as given by Prof. Eaton, are both poor, but the specimen is still in the cabinet of the Rensselaer Polytechnic Institute, bearing the original label, and I have seen several specimens of the species from the same formation. *R. dactyloides* (*Dictyocrinus dactyloides*, Conrad) is also from about the same horizon. Both of these species, however, are in the Silurian, while the present species brings the genus up to the Devonian; so that we now know of its existence from the base of the Lower Silurian to the Lower Devonian.

RADIATA.

Stylastrea Anna, n. sp.*

Pal. O., Vol. III, Plate 2, Figs. 1—5.

Corallum compound, growing in irregular or more or less hemispherical masses of several inches in diameter, which are formed of a large number of closely aggregated polygonal cell-tubes or polyps, of rather small size, divided by intercellular walls of considerable thickness, as in most forms of the compound *Cyathophyllidæ*. Full-grown polyps, measuring about half an inch in diameter, but usually somewhat smaller; the prevailing size being about three-eighths of an inch. Calyces deep, abruptly declining from the intercellular walls to a depth nearly equalling the transverse diameter. Longitudinal septa or rays well developed, extending about one-third, or less, of the diameter of the tube from the outer wall, and averaging about forty in number in adult individuals; some containing thirty-six, and one large one counted gives forty-two. Crest of the rays strongly denticulate, the denticles being thickened and knot-like at their junction with the rays. Central chamber within the limits of the longitudinal rays, equal to one-third of the entire of the polyp, and divided by numerous distinct transverse tabulæ, which are variously bent or interrupted by contact with the adjoining ones, leaving irregular cavities of considerable size between them. Interseptal spaces occupied by a series of horizontal plates, which originate at the outer wall, and extend upward and inward with increased growth to the edge of the rays, where they form the denticulation of the crest. Between the latter plates, the spaces are occupied by the smaller irregular vesicular structure.

* Named in honor of Mrs. Orton, wife of President Orton, of the State University, Columbus, Ohio.

The species, in its general features, resembles *Cyathophyllum rugosum*, Hall, sp., from this formation, and may be easily mistaken for that one, in obscure or imperfect specimens; but where the internal structure is observable, especially in longitudinal sections of the polyps, can be very readily distinguished by the large central space in each polyp, and by the strongly developed transverse tabulæ; also by the rays not extending to the centre, as in that species and in those of the genus *Acervularia*. When the coral is weathered, or the substance becomes chalky, so that the polyps are readily separable from each other longitudinally, the appearance very closely resembles that of *Cyathophyllum rugosum* when in a similar condition, but the interruption of the rays before reaching the centre, and the great extent of the tabulæ, will then serve to distinguish them.

Formation and Locality.—In the Upper Helderberg group, in Paulding County, Ohio.

BRACHIOPODA.

Streptorhynchus flabellum, n. sp.

Pal. O., Vol. III, Plate 2, Figs. 7 and 9.

Shell below a medium size, semi-circular or semi-ovate in outline, with a straight hinge-line of variable length; the lateral and front margins are somewhat regularly rounded and, in a profile view, irregularly bi-convex. Ventral valve depressed convex, with a more or less elevated and projecting but twisted or distorted beak, overhanging a nearly vertical cardinal area of irregular form and width, which is divided in the middle by a narrowly triangular convex deltidium. The dorsal valve is almost regularly semi-circular, very depressed convex, with a slightly more prominent umbo, and is destitute of cardinal area. Surface of the valves marked by from twenty-two to twenty-four strong, rather sharply elevated, radiating plications, which are entirely simple, and separated by broad, concave interspaces. The shell is also further marked by fine, regular, concentric striæ of growth, which arch backward in crossing the radii, and may have been sub-lamellose on the external surface, but the examples seen are all exfoliated.

The species is of a somewhat unusual type, especially in Devonian rocks. The dorsal valve seen alone presents so much the appearance of a strongly-marked *Aviculopecten*, that when first observed it was thought to belong to that genus; but the ventral valve, similarly marked, and possessing the characteristically twisted cardinal area and beak with its covered fissure, at once

indicates its true position. It is entirely unlike any species hitherto described from American rocks, and will not easily be mistaken. It resembles, in the features of the dorsal valve, specimens of *Orthis flabellum* from the shales of the Niagara group of New York and elsewhere; but it is more coarsely marked, with wider and more deeply concave interspaces.

Formation and Locality.—In the limestones of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by Mr. Hyatt.

Rhynchonella? raricosta, n. sp.

Pal. O., Vol. III, Plate 2, Fig. 6.

Shell of moderate size, and somewhat transversely sub-triangular in outline, when seen upon the ventral side. Ventral valve flattened and very shallow, with a short, obtuse, and not at all incurved beak; cardinal slopes incurved, and the margins straight from the beak to near the point of greatest width of the valve, the angle of divergence being nearly or quite 120 degrees. Front of the valve broadly curved, and marked by several deep indentations corresponding to the number of plications marking the surface. Middle of the valve marked by a broad, shallow, slightly angular mesial sinus, which is more than one-third as wide at the front of the valve as the length from beak to base. Surface of the valve marked, on each side of the sinus, by two low, angular, but distinct plications, besides those bordering the sinus; no other markings are traceable on the surface of the shell. The margin of the valve between the plications is extended, forming rounded projections similar to that of the mesial sinus, and probably corresponding to low rounded plications which have characterized the dorsal valve, which has not been observed.

The broad sub-triangular form of the shell, with the shallow ventral valve and the small number of low, angular plications, will readily distinguish this from any species hitherto known. There may possibly be some doubt as to the generic reference of the species; but this cannot be positively determined until more perfect individuals are obtained.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by the Hyatt brothers, of the State University.

LAMELLIBRANCHIATA.

Genus Mytilarca, H. and W.

Prelim. Notice Lamellibranchiate Shells, Up. Held., Ham. and Chemung Groups, &c. State Cab. Nat. Hist., Dec., 1869.

Mytilarca percarinata, n. sp.

Pal. O., Vol. III, Plate 6, Figs. 1 and 2.

Shell less than medium size, the specimen used for description and illustration measuring but one and three-fourths inches in extreme height; and the distance from the anterior to the posterior margins across the point of greatest diameter, only a trifle over one inch; the depth of the valve being nearly half an inch. Form of the shell elongate triangular-ovate, rather acutely pointed at the beak, which is small and incurved; anterior, or byssal, margin straight and absolutely vertical in the example mentioned; basal margin broadly rounded from the anterior line nearly to the point of greatest length of the valve, where it is more rapidly curved, and finally passes abruptly into the rapidly ascending posterior margin; the lower part of which is nearly parallel to the anterior side, but above inclines more rapidly toward the short and very oblique hinge-line. The surface of the valve is most elevated along the anterior umbonal ridge, where it is at right angles to the anterior surface, but slopes gently backward for two-thirds of the distance toward the posterior margin, and on the other third much more abruptly. Near the beak, the surface rounds rapidly from the anterior ridge to the posterior border. Surface of the shell marked by numerous concentric ridges, parallel to the margin of the valve, many of which are strongly marked and form varices of growth. On the anterior surface, these varices and the concentric striæ are well marked. Cardinal area not observed.

The example used is a right valve, and bears evidence in its characters of being an adult shell. It is associated in the same layers of cherty material with *M. ponderosa*, H. & W. (Prelim. Notice Lamell. Shells, etc., p. 21), but may be readily distinguished by the vertical anterior surface and the angular umbonal ridge. From the young of that species, it is readily distinguished by these characters, as those are distinctly round and ventricose. The only known species approaching this in the angularity of the ridge, is *M. attenuata*, H. & W., of the Chemung group; but this is quite distinct in other respects.

Formation and Locality.—In the white chalky chert-beds of the Upper Helderberg Group, near Dublin, Ohio.

GASTEROPODA.

Platyceras squalodens, n. sp.

Pal. O., Vol. III, Plate 3, Figs. 6 and 8.

Shell small, sharply conical when viewed in a lateral direction, with the apex gently curved anteriorly; but in a posterior view, the form is narrowly

lanceolate, with the dorsal portion rising into a thin, sharp crest or ridge; anterior side rounded and the anterior slope concave. Aperture narrowly ovate, rounded on the anterior side, widest just above the middle, and extending backward into a narrow point. Surface of the shell marked by fine hair-like concentric lines of growth parallel to the margin of the aperture, which is a little bent down anteriorly and posteriorly, and also by a rather faintly marked, but still distinct sulcus, which passes from the apex on the left anterior slope, and over which the striæ are slightly undulated, indicating a slight notch in the margin at this point.

In the narrow and curved lanceolate form of the shell, this species differs very materially from any of the numerous species of this very monotonous genus, and may be readily distinguished by the sharp dorsal ridge.

Formation and Locality.—In the Upper Helderberg limestone, at Columbus, Ohio. Collection of Columbia College.

Dentalium Martini, n. sp.

Pal. O., Vol. III, Plate 3, Fig. 10.

Shell somewhat larger than medium size, rather rapidly expanding from the apex to the aperture for a species of this genus, and moderately curving throughout the length; cylindrico-conical in form, and circular in a transverse section. Surface marked only by encircling striæ, which form rather broad undulations on the shell, and are strongly arched forward on the inner side of the curvature, showing that the lip of the shell has been somewhat extended on this side of the aperture. Shell-substance thick.

The species attains a rather large size, and expands more rapidly than most species of the genus, reaching a diameter of one-fourth of an inch in a length of less than two inches. The curvature is also considerable, being deflected fully an eighth of an inch from a straight line within the length of the specimen when tested on the inner face. There is no species of similar character from rocks of Devonian age, so far as can be ascertained. On some of the internal casts, there occurs a longitudinal ridge, as if there had been a slit or interruption of some kind at that point, which gives rise to a supposition that it may have belonged to the genus *Coleoprion,* Sandberger, though no positive interruption of the striæ of the surface is seen on any specimen examined. This fact may suggest its belonging to the recently formed genus *Coleolus,* Hall, but its perfect resemblance to *Dentalium* more strongly indicates its affinities as in that relation, rather than with the Pteropoda. Nor does there appear any

sufficient reason among the species referred to *Coleolus* by its author, for a generic separation from *Dentalium*, other than their more strictly straight form. But there are straight or nearly straight Dentalia, and also curved forms which he has referred to the new genus. The generic feature "shells thick" would also be opposed to pteropodous affinities. In its more rapid taper and greater curvature, it is sufficiently distinct from described forms of that genus.

Formation and Locality.—In the cherty layers of the Upper Helderberg limestones, near Dublin, Ohio.

Macrocheilus priscus, n. sp.

Pal. O., Vol. III, Plate 3, Figs. 3 and 4.

Shell small and very ventricose, the height but little greater than the diameter of the body volution ; the former in the figured example being three-eighths of an inch, and the latter only about one-sixteenth of an inch less. Shell composed of about four volutions, which are very ventricose and rapidly increase in diameter, the last one forming the great bulk of the shell, being fully two-thirds of the entire height. Suture-line distinct, but not strongly marked. Apical angle about eighty degrees. Aperture somewhat semilunate, strongly modified on the inner side by the body of the preceding volution, which occupies fully one half its height. Columella strong, straight and rounded, and the twisted ridge obsolete. Surface of the shell apparently smooth ; at least no striæ are perceptible.

This pretty little species reminds one strongly of *M. ventricosus*, Hall, from the Coal-measures, but is somewhat shorter in the spire, although resembling it in most other respects. The substance of the shell is soft and chalky, and might not retain minute surface striæ if they had ever existed ; but no remains of them are visible at present.

Formation and Locality.—In the white cherty layers of the Upper Helderberg group, near Dublin, Ohio.

Loxonema parvulum, n. sp.

Pal. O., Vol. III, Plate 3, Fig. 5.

Shell minute, scarcely exceeding a fourth of an inch in length, and proportionally slender, with a rapidly ascending spire, which is slightly more rapidly tapering in the upper than in the lower part. Volutions six or six and a half, moderately convex on the outer surface, and more strongly rounded on the lower part of the exposed portion than on the upper ;

suture-line distinct, but not margined by a flattening of the upper edge of the succeeding volution. Aperture elongate, slightly angular at the base and pointed above. Surface of the volutions marked by a large number of distinct vertical striæ, which are more numerous and slightly finer on the body volution than above, and are so nearly destitute of sigmoid curvature as to appear vertical until closely examined.

The small size of the shell, the nearly vertical lines, and the unequally expanding volutions, are distinguishing features; the latter character, however, appears to vary a little in degree on some of the specimens. It will be readily distinguished from the young shells of *L. Hamiltoniæ,* which occurs in the same rock, by the number of volutions and the slender form.

Formation and Locality.—In the white cherty layers of the Upper Helderberg limestone, near Dublin, Ohio.

CEPHALOPODA.

Trematoceras, n. gen.

A straight, obconical, cephalopodous shell, presenting the characteristics of an *Orthoceras*, so far as the appearance of the tube, septa and siphuncle is concerned; but with the additional feature of a line of elongated, raised tubercles along one side of the shell, which have formed perforations at certain stages of growth, probably confined to the outer chamber as openings, which were closed as the animal extended the shell, and before the septa opposite them were formed. Type, *T. Ohioense.*

The shell for which the above generic name is proposed offers an entirely novel feature among the Orthoceratidæ. The line of nodes seen on the cast of the shell is entirely different from anything pertaining to the ornamentation of the shell, and presents the same appearance as would the partially filled perforations of a *Haliotis,* or like those shown on the back of species of *Bucania,* and those on which the genus *Tremanotus* was founded; neither is it a feature at all dependent upon the position of the siphon or directly connected with it; for in the specimen used the siphon is slightly excentric, on the opposite side of the tube from the nodes. Its position would thus indicate that it was a feature pertaining to the dorsal lip of the shell, corresponding to the sinus seen in the lip of many other genera. Taking this view of it, it would appear to indicate the existence of a deep, narrow notch, with raised margins, in the lip of the shell at stated periods, beyond which the shell was again united for a

time, leaving a perforation to be closed by a deposit of shell from the mantle as it approached the lower part of the chamber of habitation. Many species of Orthoceras have been observed, having a raised line, or rather markings, along the dorsal side; but none, so far as I am aware, presenting these evidences of a series of separate openings, which I consider a feature worthy of generic distinction.

Trematoceras Ohioense, n. sp.

Pal. O., Vol. III, Plate 6, Figs. 3 and 4.

Shell of medium size, straight, and somewhat rapidly tapering from below upward; the rate of increase being equal to nearly one-sixth of the increase in length. Septa moderately concave, rather closely arranged; five of the chambers about equalling the diameter of the uppermost of the five counted. Siphon of moderate size, and in the specimen used slightly excentric. The surface of the shell, so far as can be determined from the internal cast, has been smooth. Perforations, or nodes representing them, large and elevated, two to three times as long as wide, and occurring at every third septum below and at every second in the upper part of the specimen.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarry, near Columbus, Ohio. The discovery and preservation of this peculiar specimen are due to the careful observation of Mr. Edward Hyatt, of the State University at Columbus, Ohio.

Gomphoceras Hyatti, n. sp.

Pal. O., Vol. III, Plate 4, Fig. 1, and Plate 5, Fig. 1.

Shell large and robust, slightly arcuate throughout, but more strongly curved below than in the upper part; somewhat rapidly expanding from below upward to near the middle of the outer chamber, where it is suddenly contracted to the aperture, and on the lateral margins again slightly expanding. The rate of increase in diameter, as compared with the increased length, is about as one and two, when measured on the inside curvature. Transverse section of the shell obtusely subtriangular, flattened or but slightly convex on the inner surface, rounded on the lateral surfaces, and obtusely rounded on the back; the dorso-ventral and lateral diameters are about as four and five, and the triangular form is more perceptible in the earlier stages of growth, owing to the greater convexity of the inner face in the upper portion and on the outer chamber. Outer chamber comparatively short, being about two thirds as high as wide. Aperture large, irregularly tri-lobed, straight on the inner face, and about four-fifths

as wide as the entire width of the shell, and apparently about two-thirds as wide in a dorso-ventral direction as laterally. The exact form of the aperture on the outer side cannot be ascertained, owing to the imperfection of the specimen in this part. Septa moderately concave, very closely arranged in the lower part, but more distantly disposed above; the rate of increase in distance somewhat gradual to near the upper portion, where two or three of the septa are slightly more crowded. In the more distant portions, three chambers occupy the space of one inch, but in the lower part of the specimen, where the transverse diameter is a little more than one and a half inches, they are less than one-twelfth of an inch apart. Siphuncle of moderate size and sub-centrally situated. Surface of the shell unknown.

The specimen from which the description is taken is an internal cast, not retaining any portion of the shelly structure, but it appears to have been destitute of strong surface markings. It measures about seven inches in length by nearly four inches in transverse diameter at the widest part, which is near the lower part of the outer chamber. The lower end is imperfect, and measures one and a half inches in transverse diameter. It is with some hesitation that I place the species under the genus *Gomphoceras*, owing to the strong curvature of the shell and the structure of the aperture, which is reversed in its relation to the curvature of the shell as compared with most species of the genus; the widest portion being on the inside curvature, instead of on the outer side. The general triangular or trilobed form of the aperture, together with the greater lateral diameter, would seem to overbalance the fact of the curvature.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Named in honor of Mr. E. Hyatt, from whose collection it was obtained.

Gomphoceras amphora, n. sp.

Pal. O., Vol. III, Plate 3, Fig. 9.

Shell of large size, elongate-ovate or short sub-fusiform, somewhat rapidly expanding from below upward to within a short distance of the base of the outer chamber; from which point it again contracts more rapidly to about one-half the height of the outer chamber, and is then drawn out into a narrow neck, resembling the neck of a bottle, of a width but little exceeding one-third of the diameter of the larger portion of the shell. Aperture not distinctly traced, but on the side figured, there is an appearance of a deep, rather narrow sinus, extending nearly one-half the depth of the outer

chamber. The shell bears the appearance, also, of having been curved, as indicated principally by the obliquity of the septa, which are numerous, rather deeply concave, and arranged at a distance of about one-fourth of an inch in the largest part of the specimen, and decreasing in distance below and above; while near the base of the outer chamber there are about six septa closely crowded together. Position of the siphuncle not determined.

The species resembles *G. eximium*, Hall, of the same formation, in the lower part of its length, although more rapidly expanding, but in the upper part, and especially near the aperture, differs entirely from any other species known.

Formation and Locality.—In the limestones of the Upper Helderberg group, in Marion Co., Ohio. Collection of Columbia College, N. Y.

Gomphoceras Sciotense, n. sp.

Pal. O., Vol. III, Plate 4, Fig. 4; Pl. 5, Fig. 2; Pl. 6, Figs. 6 and 7.

Shell of medium size or smaller, short obconical in form, or rapidly expanding from the apex upward; slightly flattened in a dorso-ventral direction, giving a broadly oval transverse section, which is a little more flattened on the dorsal than on the opposite side, in the more perfect specimen, but may not be constantly so in all individuals. Septa shallow, arranged at nearly equal distances from each other in the larger parts, and numbering about seven in an inch, except near the outer chamber, where there are usually one or two more closely arranged. The outer chamber is proportionally short, and rapidly contracted in the upper part to about one-half the diameter below, to form the transversely sub-triangular or obscurely trilobed aperture, which is rounded at the lateral extremities, straightened on the dorsal side, and provided with a moderately deep but rather narrow sinus on the ventral margin. Siphuncle proportionally small, and situated close to the dorsal side.

Only two individuals have thus far been observed, and these show some slight variation in the form of the transverse section and in the proportional length of the outer chamber; the one retaining the chambers being shorter above, and more flattened on the dorsal side than the other. In this specimen, the septa are somewhat obliquely arranged, being highest on the dorsal side, which may, however, be owing to oblique compression in the matrix. The individuals, being both internal casts, have afforded no opportunity of observing the surface structure.

Formation and Locality.—In the limestone of the Upper

Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by Mr. Hyatt.

Cyrtoceras cretaceum, n. sp.

Pal. O., Vol. III, Plate 4, Figs. 2 and 3.

Shell of medium size, somewhat moderately expanding in its upward growth to the base of the outer chamber, from which point it again contracts to the aperture ; the increase not always regular, but in some individuals more abruptly expanding above than below. Shell slightly curving throughout its length, appearing less arcuate in the upper portion, owing to the contraction of the outer chamber toward the aperture. Transverse section oval, widest in a lateral direction, and with the inner surface much less arcuate than the outer or dorsal surface. Outer chamber proportionally short, the length not exceeding the dorso-ventral diameter of the lower end ; margin simple, so far as can be determined from any of the specimens, showing only a broad, shallow sinuosity on each side. Septa somewhat closely arranged and deeply concave, but slightly increasing in distance in the upper part, the average length of the chambers being about one-tenth of an inch, but somewhat more crowded just below the outer one. Siphuncle of moderate size, situated a little within the dorsal surface, and very slightly expanded within the chambers. Surface of the shell marked only by transverse lines of growth parallel to the margin of the aperture.

The shells are moderately abundant, and show slight variations in form among individuals, especially in the rate of increase in dimensions or in the regularity of the expansion, as well as in the comparative distance between the septa ; a single individual showing a much greater distance between them in the upper part of its length. The shell would probably be considered by some as belonging to the genus *Oncoceras*, as the decrease in diameter in the upper part of the outer chamber gives to the shell, below, the peculiar bulging appearance supposed to be characteristic of that genus ; but the transverse form and elliptical section, together with the form of the siphuncle and other features, present characters common to the genus *Cyrtoceras*. It is most nearly related, in general form, to *C. Conradi*, Hall, from the Marcellus Shales of New York, but attains a much greater size, has a shorter outer chamber, and is destitute of the small lip-like sinus on the ventral side, as seen in that one. The upper portion of *Gomphoceras oviforme,* Hall, from the limestone of the Marcellus Shale, bears considerable resemblance, except in the closing of the aperture, which constitutes a generic difference.

Formation and Locality.—In the cherty layers of the Upper Helderberg limestone, near Dublin, and at Bellenaris quarry at Georgesville, Franklin Co., Ohio.

Gyroceras Columbiense, n. sp.

Pal. O., Vol. III, Plate 6, Fig. 8.

Shell of about a medium size, often attaining a diameter across the disc of about six inches, although the majority of the specimens seen will not measure more than five. The shell is closely coiled, the volutions being in absolute contact and about one and a half or two in number. Volutions nearly circular in a transverse section, being a very little greater in the lateral direction than in the dorso-ventral, and the back of the volution barely perceptibly flattened on the outer portion of the larger one, but not perceptibly so on the inner portions. Septa deeply concave and distantly arranged; the chambers measuring about half an inch each, on the outer two-thirds of the body-volution of a specimen where the vertical, or largest, diameter of the disc is five inches. Position of the siphuncle not absolutely determined. Surface of the shell unknown.

All the individuals of this species observed are internal casts, and occur in a rather rotten limestone, under conditions very unfavorable for the preservation of the shelly substance; consequently the surface-characters have not been observed. It is an abundant species, but owing to the conditions of preservation, is not often found in collections. It will be readily distinguished from the other described species by the closely coiled volutions and the nearly circular section. It is perhaps more nearly related to *G. cyclops*, Hall, 15th Rept. N. Y. State Cab. Nat. Hist., than to any other described species; but it differs from that one in its smaller size, and more rapidly increasing as well as more closely coiled volutions, and does not appear to have been provided with the broadly expanding and foliated varices which are so characteristic of that species. It might be objected, that as the shell of this species is unknown, the determination of the absence of these foliated expansions is not well authenticated; but it may be answered, that as the two species are associated in the same layers in the quarries where they are both rather common, if they were really one and the same, the shell would be preserved on these as well as on the *G. cyclops*, and the expansions readily detected.

Formation and Locality.—In the limestones of the Upper

Helderberg group, near the lower part, at Smith and Price's, and at other quarries near Columbus, Ohio.

Gyroceras seminodosum, n. sp.

Pal. O., Vol. III, Plate 4, Fig. 5.

Shell small, compactly coiled, and consisting, in the specimen used, of a little more than two volutions, which increase rather rapidly in diameter with increased age ; they are somewhat wider transversely than in a dorso-ventral direction, and are slightly triangularly elliptical in a transverse section ; the greatest transverse diameter being very slightly outside of the middle of the dorso-ventral diameter. The inner one and a half coils are smooth on the exterior, but the outer volution, for a little more than the larger half, is ornamented by a single series of comparatively large, transverse, triangularly elliptical nodes on each lateral surface, having the angular side of the node placed anteriorly and the opposite side nearly straight. The nodes are placed at distances from each other about equal to one-half the dorso-ventral diameter of the tube at the node indicated. The septa are not clearly defined and cannot be given with certainty; but they appear to be distantly placed on the inner portions of the shell, while on the nodose portion they seem to be placed at about half the distance of the nodes apart. The siphuncle has not been observed. The surface of the shell, as seen on a fragment of the substance remaining on the dorsum of the outer volution, is marked with rather close, distinct, revolving lines or ridges, crossed by more closely arranged transverse lines, which make a shallow retral bend in crossing the back of the shell.

The specimen is probably an immature shell, but is a distinctly marked species, differing strongly in its form and nodose character from any of those assoeiated with it. It most nearly resembles *G.* (*Hercoceras?*) *paucinodus*, Hall, from the Upper Helderberg group of New York (see Illust. Dev. Foss., Pl. 55, Figs. 1 and 2), but is less distinctly triangular in a transverse section, that one being widest near the outer portion of the volution, with a nearly regular sloping surface on the side of the whorl to its junction with the preceding one, while this species is rounded. The form of the nodes is also different—those being situated near the dorsal margin. The triangular form of these nodes is peculiar in having the two short sides of the triangle directed forward. It also differs in having a greater number of volutions for a given diameter.

Formation and Locality.—In limestone of the Upper Helderberg group, near Dublin, Ohio. Collected by Mr. Hyatt, of the State University, at Columbus, Ohio.

Species from the Marcellus Shales.*

The following species occur in a highly bituminous brown shale, of but a few feet in thickness, and having intercalated beds of thin shaly limestone associated with it. The bed occurs near the upper part of the limestones heretofore referred to the Upper Helderberg group in Ohio, and below the layers known as the Delaware stone, characterized by an abundance of remains of Devonian fishes. These black or brown shales, so far as yet explored, contain only the following species. most of which are known forms, and some of them characteristic species of the Marcellus Shales of New York. The species *Lingula Manni*, Hall, occurs in the upper blue layers of the Delaware beds at Delaware, and in a corresponding position at other localities, but so far as yet known does not occur in the lower portions of the group. At one of the localities where the fossils were obtained from the brown shales, the layers immediately above these beds are thickly covered with specimens of *Tentaculites scalariformis*, Hall, and *Spirifer gregaria*, Clapp; and although both these species may be occasionally found at a lower horizon. they are never abundant except in the upper part of the group, and are unknown in the lower part. Judging from these circumstances, together with the lithological character of the shales and the known position of the species occurring in them, it would appear reasonable to consider these brown bituminous shales and limestones as being the western representatives of the Marcellus Shales of New York; while the beds above them, characterized by the presence of large numbers of *Tentaculites* and *Spirifer gregaria*, would appear to represent the Hamilton group of New York. In pursuance of this idea, several sections have been critically examined in Central Ohio, and it is found that the blue Delaware stone is followed by rapid repetitions of brown shale, and thin-bedded shaly limestones, and finally by soft, blue, muddy shales, resembling the Moscow shales of New York, which are followed by beds of thin fissile black shales, representing the Genesee slates of the New York series.

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* In Vol. V, Pal. N. Y., on pp. 146 and 147, after speaking of the section of rocks at the Falls of the Ohio, and the probability that the hydraulic cement bed and the layers above it, up to the base of the Black Slates, are of the age of the Hamilton beds of New York, the au-

The species recognized and described as occurring in the shales above referred to are as follows; most of them being previously known. The species marked as new are described below.

Lingula Manni, Hall.
Lingula Ligea, Hall. ?
Discina minuta, Hall.
Discina Lodensis, Hall.
Chonetes scitula, Hall.
Chonetes reversa, n. sp.
Spirifera Maia, Billings' sp.
Leiorhynchus limitaris, Vanuxem's sp.
Aviculopecten equilatera, Hall's sp.
Pterinea similis, n. sp.

Chonetes reversa, n. sp,

Pal. O., Vol. III, Plate 7, Figs. 8 and 9.

Shell of about a medium size, semicircular in outline, with a long straight hinge-line exceeding the width of the shell below. Valves resupinate, or reversed in their curvature ; the ventral being very slightly convex in the earlier stages of growth, and subsequently recurved so as to appear concave ; the entire deflection from a plane being very little, so that the general appearance of this valve may be said to be nearly flat. Area linear. Hinge-line ornamented by four long, very slender spines on each side of the centre, which are projected from the hinge-line at an angle of about 65 degrees, measured on the outside, or 115 degrees as counted on the inside of the spine. Surface of the ventral valve marked by exceedingly fine striæ, which are slightly alternating in size ; there being from two to five finer ones between the coarser kind. Interior of the valve characterized by fine pustules, arranged in indistinct lines, presenting the usual characteristics of the genus. Dorsal valve not positively known; but there is associated with it, in the same layers, a slightly convex valve with similar striæ, but more distinctly alternating, which may possibly represent this valve. Its form is similar, and the convexity correspondingly great.

This species is peculiar in its resupinate character, so far as

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thor says: "In the State of Ohio similar conditions may be inferred, from the fact that certain species of Hamilton fossils are published in the Ohio Geol. Rept. as from the Corniferous group." By reference to the 28th Vol. of the Proc. of the Am. Association for the Advancement of Science, p. 297, it will be seen that, at the Saratoga meeting of the Association, I read a paper on the discovery of the Marcellus Shale in Ohio : in which it is stated that the rocks above that horizon (the Marcellus) would necessarily be Hamilton. This was in August, 1879. The volume above-mentioned is dated, in the letter of transmissal, Dec. 15th, 1879.

the genus is known in American Devonian rocks, and this character, together with its form, its fine striæ, and its nearly erect slender spines, will readily distinguish it from any other species. The dorsal valve above spoken of was at first supposed to be the young of *Strophodonta perplana*, Conrad's sp., but the similarity in size and character of striæ to this species renders it doubtful.

Formation and Locality.—In thin-bedded bituminous limestone, from above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio.

Pterinea similis, n. sp.

Pal. O., III, Plate 7, Fig. 15.

Shell small, oblique; the body, exclusive of the wings, being almost regularly although obliquely ovate in outline, the anterior part being the larger; hinge-line about two-thirds as long as the entire length of the valve; anterior wing small, distinctly rounded on the end, and separated from the body of the shell, on the left valve, by a distinct sulcus along the surface, and which constricts the margin of the shell; posterior wing one-third longer than the anterior side, pointed at the extremity and sinuate below. Body of the valve ventricose, strongly so on the umbone, with a strong tumid beak, which projects distinctly beyond the hinge. Surface of the left valve marked by distinct radii, which are plainly alternated in strength over the body of the valve, but less distinctly so toward and on the wings; also, by less strong concentric lines, and varices of growth. Right valve unknown.

The shell is of the type of *Pterinea decussata*, Hall, which occurs abundantly in the Hamilton group in New York, but is of extremely small size, and very ventricose; the proportionally strong varices of growth showing its adult character. The type is one represented in the Devonian rocks, from the Hamilton to the top of the Chemung, inclusive, in New York, by several distinct species, but which is seldom recognized below this horizon. We may, therefore, consider it as an additional evidence of the age of the beds in which it is found.

Formation and Locality.—In the thin shaly layers of bituminous limestones, from above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio.

The following species are from the limestones above the "Bone-bed," which rest on the top of the Marcellus Shale, in the vicinity of Columbus, Ohio, and are not known to pass below that horizon at any locality in that region.

Gilbertsocrinus spiniferus—*Trematocrinus spinigerus*, Hall; 15th Rept. N. Y. State Cab., p. 128;—*Gilbertsocrinus* (*Trematocrinus*) *spinigerus*, Hall; Descr. of New Species of Crinoidea, from the Carbonif. Rock of the Miss. Valley, Plate 1, Fig. 9.

Spirifera ziczac, Hall.
Pterinea flabella, Conrad's sp.
Grammysia bisulcata, Conrad's sp.

Actinodesma subrecta, n. sp.

Pal. O., Vol. III, Plate 7, Fig. 20.

Shell of moderate size; the body of the shell, exclusive of the wings and hinge-extensions, ovate in outline, and slightly oblique to the cardinal line. Hinge-line extended in the form of strong auriculations or wings on the sides of the shell, the upper margin straight, or a little declining on each side of the beak; anterior wing short, triangular, and divided from the body of the shell by a deep and wide sub-triangular notch ; posterior side long and submucronate at the extremity, three to three and a half times as long as the anterior side, and its area much greater, extending along the body of the valve to nearly half its length from the beak. Body of the left valve more than moderately convex, and strongly arcuate or bent between the beak and base of the shell ; so that when placed on a flat surface, the margin, especially on the posterior side, would be much elevated above the plane. Beak of the valve large, sub-tumid, and slightly extended above the cardinal line. Length of the body of the shell, from the cardinal line to the base, about one-fifth greater than across it in the opposite direction. Anterior border broadly rounded, the basal margin more sharply so, with a slight angularity at its junction with the nearly direct posterior border. Surface of the shell marked by irregular, concentric, strongly lamellose lines, resembling those of the oyster. Right valve not yet observed from Ohio.

The species is allied to *A. recta*—*Avicula recta*, Conrad, but is shorter, more ventricose on the left side, more arcuate or bent, and with less extended wings. It is not an uncommon species in the soft shales of the Hamilton group of New York, where it is readily recognized from *A. recta* by the above-mentioned characters. The *A. recta* is most common in the arena-

ceous beds of eastern New York, while this is the prevailing form among the soft shales farther west. The right valve is there recognized as being shorter than the left, concave instead of convex, with an appressed beak or umbo not extending beyond the cardinal line, and the valve is much thinner in its substance.

Formation and Locality.—In layers of brownish limestone above the "Bone-bed," at Fishinger's mill, Franklin Co., Ohio. Collected by the Hyatt brothers, of the State University at Columbus.

Genus **Nyassa**, H. & W. Prelim. Notice of Lamellib. Shells of the Up. Held., Hamilton and Chemung Groups, etc. N. Y. State Cab. Nat. Hist., Dec., 1869, page 28. [Generic description omitted. R. P. W.]*

Nyassa arguta,

Pal. O., Vol. III, Plate 7, Fig. 18.

Nyassa arguta H. and W. Prelim. Notice of the Lamellib. Shells of the Upper Held., Hamilton and Chemung Groups, etc., distributed without author's name, Dec., 1869, p. 28.

Shell of medium size, transversely sub-ovate or sub-trapezoidal, much longer than high. Valves moderately ventricose, most prominent along the umbonal ridge, which is rather strongly arcuate and sub-angular. Beaks rather small and appressed, slightly incurved, and situated near the anterior end. Surface of the valve generally declining from the umbonal ridge to the basal line, and with a slight sinus or sulcus below the ridge, which gradually widens toward the margin of the shell, where it causes a broad, but not marked, emargination in the border of the shell. Cardinal slope narrow and abrupt; hinge-line arcuate; posterior end of the shell narrowed ; anterior end broad, rounded, and slightly excavated below the beaks.

Surface of the shell marked by concentric lines of growth parallel to the margin of the valve, and often forming rather strong, irregular varices, most distinctly marked on the anterior half of the shell.

The Ohio specimens, although preserved in an entirely different matrix, are yet such exact counterparts of the New York shells that no question can exist of their positive identity.

Formation and Locality.—In limestone above the Bone-bed in Tully township, Marion Co., Ohio. The specimen figured is from the State Cabinet at the State University, Columbus, Ohio.

Genus **Palæoneilo,** H. & W.

Preliminary Notice of Lamellib. Shells of the Upper Held., Hamilton and Chemung Groups, etc., N. Y. State Cab. Nat. Hist., Dec., 1869, p. 6.

* See note at the close of this article.

Palæoneilo similis, n. sp.

Pal. O., Vol. III, Plate 8, Figs. 4 and 5.

Shell oblong, with nearly equally rounded extremities, and almost parallel dorsal and ventral margins. Anterior end short, a little narrower than the body of the shell, resulting from the constriction below the beaks. Posterior end rounded, with a slight oblique truncation below the middle of the height, corresponding to the very shallow umbonal sulcus of the valves. Beaks situated within the anterior third of the length of the shell, small and enrolled. Valves ventricose, most prominent just below the umbones, and slightly sulcated along the posterior slope. The surface of the shell, so far as can be determined from the matrix, has been smooth or without visible markings. On the internal cast, the condition in which the specimens are found, the muscular imprints are faintly marked—the pedal muscles being the most distinct.

The species is closely related to *P.* (*Leda*) *Barrisi*, White and Whitf., Proc. Bost. Soc. Nat. Hist., Vol. 8, p. 298,(*Palaeoneilo Barrisi* (W. and W.), H. & W., Prelim. notice of Lam. Shells of the Up. Held., Hamilton and Chemung groups, etc.,), but has been somewhat more nearly parallel on the margins, and has a smoother shell.

Formation and Locality.—In the calcareous concretions of the Erie shale, at Leroy, Lake Co., Ohio, accompanying the fossil entomostracan from the same locality (next described).

CIRRIPEDIA.

Plumulites Newberryi, n. sp;

Pal. O., Vol. III, Plate 8, Figs. 6—11.

The specimens for which the above specific name is proposed, consist of several detached plates, and of one of several plates, irregularly folded together in such a manner as to be difficult of interpretation. The several plates vary considerably in form among themselves, and probably represent those from different parts of the body.

The general form of the plates is triangular, with the apex, or initial point of growth, a little inclined to one side; the base, or margin of accretion, is usually the longest side, but not in all cases. One set of plates has the shorter sides diverging at nearly right-angles. On this form, the basal line is convex for more than two-thirds its length, and concave on the remaining por-

tion, giving a sigmoidal outline; of the shorter sides, one is straight to near the apex, where it becomes rounded, and the other is slightly concave. Another form has the shorter sides diverging at an angle of about 105 degrees, one slightly convex and the other concave; while the basal margin is convex in two sections, with a constriction or interruption between the two sections, or at about one-third of its length from the straight margin. The plates of this and the preceding form have the surface regularly annulated transversely, parallel to the basal margin, the annulations very fine, and regularly increasing in size and strength from the apex to the base, except in aged specimens, where they are again crowded near the border: five undulations may be counted in an eighth of an inch, where strongest. These forms, also, have the straight margin often fractured and bent, as if they had been broken along that side; indicating that two such plates may have been united along this line; and on the only individual showing several plates together, this would appear to be the case. A third form of plate is narrowly triangular or conical, the basal border being the shortest, and simply convex; the other sides being slightly curved throughout, but more distinctly so near the apex, which is obtusely rounded; the lateral margins are of unequal length, and the annulations of the surface finer and more closely arranged than on the other forms.

The individual specimens are much too few in number to give any very satisfactory idea of the general form of the complete body, or of the number of ranges of plates of which it may have been composed. There appears to be no reason, however, to doubt the correctness of the reference of these plates to the genus *Plumulites*, Barrande, as their general form and surface structure is exactly like those given by Dr. Barrande, and also to those given in Vol. II, Pal. Ohio, Pl. 4, Figs. 1 and 2 (*P. Jamesi*), as occurring in the rocks of the Hudson River group, at Cincinnati; while some idea may be obtained of the probable form of the entire body from the outline figure of a European species, represented in Fig. 3 of the same plate. These Devonian specimens, however, have been of very much greater size than the above, as the plates here figured are all represented of natural

size, the larger individual plates being more than an inch in transverse diameter, while the species above referred to is minute. The occurrence of forms of this genus in rocks of Devonian age is also a new feature in its history; as those of Europe are confined to the Lower Silurian formations and the lower beds of the Upper Silurian; while these occur above the middle Devonian.

Formation and Locality.—In the Huron shale at Sheffield and Birmingham, Erie Co., Ohio; equivalents of the Genesee slates and Portage group of New York.

The following species are from the Maxville limestone of Maxville, Newtonville, and the neighboring parts of Ohio, equivalent to the Chester limestone, or Chester and St. Louis limestones, of the Mississippi Valley.

CRINOIDEA.

Cyathocrinus inequidactylus, n. sp.

Pal. O., Vol. III, Plate 9, Figs. 5—8.

Body of rather small size. Calyx deep cyathiform, being nearly hemispherical in one example, and somewhat broad obconical in another, and composed of smooth plates, which have only the general convexity of the the body, or very slightly tuberose. Basal plates minute to moderate size, higher than wide. Sub-radials large; height and width nearly equal; two of them heptagonal and the others hexagonal, the lower sides barely diverging from a straight line. First radials wider than high, and about two-thirds as high as the sub-radials. Anals visible, three in number; the first elongate pentagonal, nearly twice as high as wide, and situated a little obliquely on the right side of the area; the other two are small and pentangular. Second radials, or first arm-plates, smaller than the first radials and narrowing upward, wedge-formed above, and each supporting two arms. On the postero-lateral rays they are long and cylindrical, with the arms slender. On the anterior ray it is short and supports two slender arms; while on the antero-lateral rays they support a slender arm similar to those of the other rays on the anterior side, and on the outer side an arm several times larger and stronger than the others, and composed of larger and stronger plates.

Plates of the arms short and unequal-sided, and giving origin to jointed tentacula from the longer side of each plate, which is upon the alternate sides of the arm, or on the same side from every second plate. Surface of the plates smooth. Length of the arms and subsequent bifurcations not known. Column small, round, and composed of unequal-sized plates alternating with each other.

The slender arms are preserved on two individuals to the length of about

one inch, and the strong antero-lateral arm on one, to more than an inch; but no evidence of bifurcation appears.

The inequality of the antero-lateral arms will be the distinctive feature of the species, as the form of the calyx is similar to many other species of the group.

Formation and Locality.—In the Maxville limestone (shaly portion), at Newtonville, Ohio.

BRYOZOA.

Synocladia rectistyla, n. sp.

Pal. O., Vol. III, Plate 9, Figs. 9 and 10.

Bryozoum growing in spreading funnel-formed fronds, rising from a rooted base and widely diverging in their upward growth; the inner surface of the cup bearing pores. Rays straight and somewhat rigid in their upward direction, with frequent bifurcations, which are not abrupt with rapidly diverging branches, but rise gradually from a thickened space, and gradually diverge as slender but constantly thickening rays until the normal strength is attained.

The rays are slender, rather closely arranged; about six of them occupying the space of a fourth of an inch in the widest parts, and from eleven to twelve may be counted in the same space in the most crowded parts.

Transverse dissepiments nearly as strong as the longitudinal rays, and often slightly arched upwards between them in the wider parts, but more frequently directed obliquely upward in passing from one ray to the next, and very often directed upward to the right from one side of a ray, and to the left on the opposite side; but they are generally direct in the more crowded portions. The middle of the ray on the poriferous surface is elevated or roof-like, with a central crest or ridge bearing distant nodes; a single row of large pores is arranged on each side, which are usually less than their own diameter apart, and more or less alternating with those of the opposite side. From two to three pores occupy each side of each fenestrule, and the pores are margined by an elevated lip, which on unworn spaces are very prominent. From one to three similar pores, although sometimes of smaller size, occupy the surface of each dissepiment. Non-poriferous surface not observed.

This species is somewhat similar to *S. biserialis*, Swallow (Trans. St. Louis Ac. Sci., Vol. I, p. 179), as identified and figured by Mr. F. B. Meek (Final Rept. of U. S. Geol. Surv. Neb., pl. 7, fig. 5), but differs in wanting the longitudinal nodose ridge between the pores of the dissepiments, and in having only a single row of pores on those parts occupying the

middle of the dissepiment, as well as in the more slender, finer and more direct, and much more crowded rays, also in having a larger number of somewhat smaller pores on the rays. Mr. Meek, *loc. cit.*, identifies the above species with *Synocladia Cestriensis* (*Septipora Cestriensis*, Prout, Trans. St. Louis Acad. Sci., Vol. I, p. 448, pl. 18, fig. 2), which differs from the Ohio specimens in the stronger and thicker, as well as more flexuose rays; in the rounded fenestrules, and smaller-sized pores, which are also more abundant, often showing three ranges on parts below bifurcations. On direct comparison of the Newtonville specimens with specimens from Chester, Ill., these differences, especially those pertaining to the mode of growth, are very marked and characteristic.

Formation and Locality.—In the Maxville limestone (Chester), at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

LAMELLIBRANCHIATA.

Pinna Maxvillensis, n. sp.

Pal. O., Vol. III, Plate 10, Fig. 5.

Shell of about a medium size, very acutely triangular in outline, with highly convex valves; the length along the hinge equal to nearly three times the greatest width. Hinge-line straight, not quite as long as the shell below; anterior end acute; basal margin very slightly arcuate, and the posterior extremity rather broadly rounded; the point of greatest length being at about one-third of the width below the hinge-line. Surface of the shell, except for a short distance within the basal margin, marked by moderately strong, simple radiating plications, about eighteen in number, as counted at the posterior end of the specimen figured, but increasing in number with increased growth; the additions being near the hinge. There are also numerous strong concentric lines of growth parallel to the margin, often forming undulations of the surface.

I find no American species described that closely resembles this one; but *P. flexicostata*, McCoy, from the English Carboniferous rocks (British Pal. Foss., p. 499, pl. 3, E, figs. 11—13), is very similar, but has slightly stronger radii, is somewhat broader, and differs in having a longitudinal depression just below the hinge-line, which this species does not possess.

Formation and Locality.—In the Maxville limestone, at Maxville, Ohio. Collection of Prof. E. B. Andrews.

Allorisma Andrewsi, n. sp.

Pal. O. Vol. III, Plate 10, Fig. 6.

Shell of medium size or smaller, transversely elliptical in outline ; the length being about twice the height, and the thickness a little more than two-thirds the height. Valves ventricose, most rotund a little in advance ot the middle and along the umbonal ridge, and wedge-shaped posteriorly, as seen in a cardinal view; beaks of moderate size, slightly projecting above the hinge-line, incurved, directed anteriorly, and situated at about one-sixth of the entire length from the anterior end. Cardinal line straight or appearing slightly concave, extending about three-fourths of the length of the shell from the beaks backward, and bordered by a proportionally large and wide escutcheon. Anterior end short, sloping forward from between the beaks, at about an angle of forty-five degrees to the hinge-line, to near the middle of the height of the shell, and then abruptly rounding backward into the somewhat regularly convex basal margin. Posterior end broadly rounded from the point of the umbonal ridge to the extremity of the cardinal line. Anterior end of the shell characterized by a very small lunule. Surface of the shell marked by several strong concentric undulations or folds, which are simple, and regularly increase in size and strength to near the full size of the shell; but near the outer margin of the valves, in the specimen figured, they are smaller and doubled by the interpolation of an intermediate rib. The undulations are crossed obliquely from the beak to the basal margin, just posterior to the middle, by a narrow, almost imperceptible sulcus, and along the crest of the umbonal ridge by a line of low-convex and faintly-marked nodes, one on the surface of each undulation; the posterior umbonal slope is also marked, immediately below the margin of the escutcheon, by a slightly concave sulcus, across which the undulations are more faintly marked than below.

The species is closely allied to *Allorisma clavata*, McChesney, and was at first supposed to be identical ; but on comparison, it shows so many points of difference that it became necessary to consider it as a distinct species.

Formation and Locality.—In limestone of the age of the Chester group (or Chester and St. Louis combined), at Newtonville, Ohio. Collected by Prof. E. B. Andrews, to whom the species is dedicated.

Allorisma Maxvillensis, n. sp.

Pal. O., Vol. III, Plate 10, Figs. 7 and 8.

Shell small, the specimen used being a little less than one inch in length, and the height less than half the length. Form of the shell transversely

elongate, and cylindrically oval, the cardinal and basal margins parallel and very slightly curved, and the extremities very nearly equally rounded; beaks small, inrolled, barely projecting above the cardinal line, and situated at about one-fourth of the entire length from the anterior end. Body of the shell very evenly and highly rounded from the cardinal to the basel margins, and almost as convex posteriorly as in front. Umbonal ridge scarcely perceptible, and the umbonal slope convex; escutcheon and lunule not defined; anterior slope abruptly rounded. Surface of the shell marked by faint concentric undulations of unequal strength, but most strongly marked on the posterior end and on the umbonal slope.

The evenly convex and regularly cylindrical form of the shell, together with the inconspicuous beaks and the equal-sized anterior and posterior extremities, are distinguishing features of the species. The shell shows evidence in its form and curvature, in a profile view, of having been slightly gaping behind.

Formation and Locality.—In limestone of the age of the Chester group of Illinois, at Newtonville, Ohio.

GASTEROPODA.

Naticopsis zic-zac, n. sp.

Pal. O., Vol. III, Plate 10, Figs. 15 and 16.

Shell small, the greatest diameter of the body-volution, in the only individual seen, being about nine-sixteenths of an inch; and the entire vertical height of the shell only half an inch. The shell is very obliquely ovate in form, and consists of about two and a half ventricose volutions, which increase somewhat rapidly in size to the last one, which forms nearly the entire bulk of the shell. The surface of the shell is ornamented by a series of strong and raised transverse lines, which, on the upper volutions, are simple as far as the suture below, and are directed strongly backward in their passage; but on the body-volution they appear more distant and conspicuous, and are directed strongly backward in their passage for about one-third the vertical diameter of the volution, where they are bent forward at an acute angle, and after continuing for a distance nearly equal to their length above, are again bent backward. Across the midde of the volution, they make two or more zig-zagging bends in vertical lines, forming a revolving band of vertical ridges on the periphery; below this band, the lines are directed forward obliquely, running nearly parallel to the base of the shell.

The peculiarity of this shell consists entirely in the structure of the surface ornamentation, as the general form of the species

is similar to that of many others, but the peculiar zig-zag feature of the ornamenting ridges will at once distinguish it from all other described species. Several ornamented forms of the genus are known from the Coal-measures, but their markings consist of nodes, either promiscuously scattered or arranged in patterns.

Formation and Locality.—In the limestone of the age of the St. Louis and Chester beds of Illinois (Maxville limestone), at Newtonville, Ohio.

Holopea Newtonensis, n. sp.

Pal. O., Vol. III, Plate 10, Fig. 12.

Shell of medium size, ovate in outline and ventricose, with a moderately elevated spire and extremely ventricose volutions, which increase very rapidly in bulk from the apex. Volutions three and a half to four in number, with strongly rounded surfaces and moderate sutures. Apical angle about seventy degrees. Aperture broad ovate, modified on the inner side by the preceding volution, pointed at the upper end and broadly rounded at the base. Surface of the shell smooth and the substance very thin

The form of the shell is much like that of a *Macrocheilus*, but the substance is much thinner than those usually are, and the base of the columella is not prolonged, nor is there a solid axis; but specimens show satisfactory evidence of having been distinctly and largely umbilicated.

Formation and Locality.—In the Maxville limestone (Chester), at Newtonville, Ohio. Collection of Columbia College, N. Y.

Macrocheilus subcorpulentus, n. sp.

Pal. O., Vol. III, Plate 10, Fig. 14.

Shell small, the specimens observed not exceeding five-eighths of an inch in length, and the diameter rather exceeding half the length; spire conical, the apical angle being about fifty degrees. Volutions about three or three and a half, rapidly increasing in diameter and very ventricose, the last one forming more than half the length and much the greater bulk of the shell; suture deep and well marked. Aperture ovate, short and oblique. Surface of the shell smooth. Columella not seen.

This species is rather closely related to several forms which have been described from the Coal-measures of the Western States, but differs in the form of the volutions somewhat from

any, and in the more regular tapering spire,—those mostly having the body-volutions proportionally enlarged.

Formation and Locality.—In the Maxville limestone (Chester and St. Louis groups), at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

Polyphemopsis melanoides, n. sp.

Pal. O., Vol. III, Plate 10, Fig. 13.

Shell rather below a medium size, elongate-fusiform ; the length nearly twice and a half the greatest diameter, when not compressed ; spire elevated, pointed at the apex, the apical angle being about thirty-five degrees when uncompressed. The specimen figured gives on measurement thirty degrees in the line of compression, and forty degrees in the opposite direction. Volutions about five and a half, gradually increasing in size, moderately and evenly convex, with distinct sutures. Aperture elongate ovate, widest across the middle, rounded and effuse below and pointed above. Columella not observed. Surface apparently smooth.

The species is nearly of the form of *M. fusiforme,* Hall (Geol. Rept. Iowa, Vol. I, Part 2), from the Coal Measures of Iowa, but is considerably more slender. It is possible it may not properly belong to the genus, as the columella has not been closely observed; but so far as can be determined, it appears to be twisted.

Formation and Locality.—In the Maxville limestone, at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

Bellerophon alternodosus, n. sp.

Pal. O., Vol. III, Plate 10, Figs. 17—19.

Shell of about a medium size, and somewhat subglobose in general form, with an appearance of being slightly flattened on the dorsum in immature specimens ; while on the adult forms, the dorsum is marked on the outer half of the body-volution by a double series of rounded nodes, those on one side of the centre alternating with those of the other side, and the inner margins of the two series interlocking with each other. Aperture broadly elliptical, strongly modified by the projection of the preceding volution, on the inner margin. Auriculations largely developed and slightly reflected. Axis very distinctly perforate. Inner lip somewhat callous on the protruding inner volution. Surface of the shell, so far as can be ascertained, marked only by lines of growth, beyond the nodes mentioned.

The species is somewhat similar in general form to *B. Montfortianus,* N. and P., from the Coal Measures, in its general form, but does not possess the strong transverse folds nor the

carina between the lines of nodes marking the dorsum. It also differs in the alternating positions of the nodes.

Formation and Locality.—In the Maxville limestone at Newtonville, Ohio. Collection of Columbia College, N. Y.

CEPHALOPODA.

Nautilus pauper, n. sp.

Pal. O., Vol. III, Plate 10, Fig. 23.

Shell somewhat below the medium size, and consisting of about two and a half volutions, which increase rather rapidly in size, and are so coiled as to expose almost the entire diameter of the inner coils in the umbilical cavity ; the outer one embracing only the dorsal surface of the inner volution. Volutions quadrangular in form, with the lateral diameter only about two-thirds as great as the dorso-ventral diameter ; while the dorsal and ventral surfaces are nearly vertical to the plane of the sides, so far as can be determined from the specimen in hand ; or possibly the dorsal surface may be slightly rounded. The sides of the shell are marked by a faint, narrow, revolving sulcus bordering the margin of the umbilicus, and by a correspondingly faint ridge close to the dorsal margin; while a much stronger rounded ridge occurs on the surface at about one-third of the width of the volution from the dorsal border. Internal features of the shell not known.

A single individual only of the species has been observed, and is altogether too imperfect to reveal all the features. It consists of the non-septate portion of the shell, in the condition of an internal cast, with the impression of one side of the entire shell ; but gives no indications of the septa themselves. The only features indicating its cephalopodous nature, upon which one can rely, are its symmetrical form, and the evidences of a similar ornamentation on the opposite sides ; otherwise it might have been supposed to represent a form of *Euomphalus.*

Formation and Locality.—In the Maxville limestone (Chester), near Rushville, Ohio. Collection of Prof. E. B. Andrews.

Fossils from the Coal Measures.

CRINOIDEA.

Cyathocrinus Somersi, n. sp.

Pal. O., Vol. III, Plate 11, Figs. 4 and 5.

Calyx very shallow, being low and spreading; the extreme height to the top of the first radial plates not exceeding one-fourth of the diameter ; the

sides, above the middle of the sub-radial plates, gradually and almost evenly curving. Centre of the calyx below deeply impressed, the cavity embracing the basal and inner half of the sub-radial plates. Basal plates very small, extending but little beyond the circumference of the proportionally small column, and forming by their union a somewhat regular pentagon. Sub-radial plates of medium size, four of them being equal, and pointed at their upper ends, the upper edges being convex ; the fifth plate is larger than the others, and is truncated above by the very small first anal plate, which rests between the adjacent first radials, and has apparently joined three other plates above. The surface of this plate bears a single round granulose tubercle. First radial plates nearly twice as wide as high; their lateral faces being short and uniting with those of the adjacent plate, except on the anal side, where they are separated by the first anal plate. Articulating face for the second radials nearly straight, but deeply grooved. Second radial plates short; that of the anterior ray being cuneiform above, and has supported an arm-plate on each upper sloping surface. The second radials of the other rays have not been fully determined; but on the antero-lateral rays, where partially detached plates remain, they have been quadrangular, as if for the support of other radial plates in a direct series. Surface of the inner half of the sub-radial plates smooth, while the outer half and the entire surface of the other plates are covered with proportionally large, distinct, irregular tubercles, which are flattened on their surfaces and covered with numerous small, distinct granules. The granules also extend to parts of the intermediate surface. The upper margin of the first radial is bounded by an elevated transverse ridge, which is also granulose.

This species bears considerable resemblance in its general surface-markings to *Eupachycrinus tuberculatus*, M. and W. (Geol. Surv. Ills., Vol. V, Pl. 24, Figs. *a*, *b*), but the tubercles are very distinctly granulose. It, however, does not possess the structure of *Eupachycrinus*, having only one small anal plate, the upper end of which projects above the line of the first radials. The only specimen yet obtained of the species measures about three-fourths of an inch in diameter, and is about three-sixteenths of an inch high to the top of the first radial plates.

Formation and Locality.—In the Coal-measures at Carbon Hill, Hocking Co., Ohio. Collected by Mr. Somers, of Columbus, Ohio.

Zeacrinus Mooresi, n. sp.

Pal. O., Vol. III, Plate 11, Figs. 6—10.

Form of entire body unknown. Calyx of moderate size and pentagonal in outline, very broadly cyathiform or shallow cup-shaped ; the region of the basal plates being impressed, and the radials but moderately curving

upward at their outer edges. Basal plates small, forming by their combination a nearly regular pentagon. Sub-radials proportionally large, wider than high, four hexagonal and one on the anal side heptagonal. Sub-radials short, but not very broad, twice to twice and a half as wide as long ; the cicatrix for the second radials very large and nearly straight. The anal plates, three of which are preserved, are longer than wide. Column small, round, composed near the calyx of alternately small and large plates, with very coarse radiating lines of articulation. Surface of calyx smooth, except a line of granules just within the margin of the sub-radial plates.

The second radial plates present the strong specific feature of the species, and are large and spine-bearing, as in *Zeacrinus mucrospinus*, McChes. The spines are long, much thickened and bulbous in the lower part, presenting in this respect a strong contrast with those of that species. The cicatrix for the attachment of the arm-plates is very large, showing that the plates above were of large size. Arms and dome unknown.

The species has been quite abundant, as the spines are found in great numbers, and vary considerably in size, according to the width of the first radial plates upon which they have rested. But all are thickened and bulbous, and many of them are more than an inch in length. They are seldom found attached to the calyx, but are scattered through the shale in the bed where found.

Formation and Locality.—In shale of the Coal-measures at Carbon Hill, Hocking Co., Ohio. Named in honor of H. Moores, Esq., of Columbus, Ohio, their discoverer.

BRACHIOPODA.

Discina Meekana, n. sp.

Pal. O., Vol. III, Plate 11, Figs. 1—3.

Discina nitida ? (Phil.) M. and W., Geol. Ills., Vol. V, p. 572, pl. 25, fig. 1;—*not D. nitida*, Phillips, Geol. Yorkshire, Vol. II, p. 221, pl. 11, figs. 10—13.

Shell of moderate size or larger, circular or sub-circular in outline. Dorsal valve convex, with an elevated beak which is directed backward and situated at about one-third of the length of the shell from the posterior margin. Posterior slope slightly concave just below the apex; anterior slope convex. Surface of the shell, when preserved, marked by fine, even, but elevated and regular concentric lines, with flattened interspaces ; about ten or eleven of the elevated lines occupy a space of an eighth of an inch on the middle of a shell, being finer within and coarser beyond that point. On the partially exfoliated shell, fine radiating vascular lines are perceptible. Ventral

valve flat, discoidal, circular in outline, or perceptibly elongated in some cases ; the apex a little more than one-third the length of the shell from the posterior margin. Foramen small, elongate-elliptical, narrow, not extending more than one-fourth of the distance from the apex toward the margin, and the depression somewhat further. Surface marked as in the other valve.

This shell would appear to be identical with the one described and figured by Messrs. Meek and Worthen as *D. nitida?* under the supposition that it was the same as that figured by Prof. Phillips, in the Geol. Yorkshire Coast, Vol. II, pl. 11, figs. 10—13 ; but it differs very much in outline from those figures, as well as those given by other authors, in its circular form ; those being ovate, narrowed behind and widened in front ; also, in having the apex much more distant from the margin. They also cite *D. Missouriensis*, Shumard, as a synonym of the European species. That author indicates his shell as parabolic in outline; from which statement I should consider it as distinct from the present species.

Formation and Locality.—In the Coal-measures at Carbon Hill and Flint Ridge, Ohio ; also in Illinois and Iowa.

Crania carbonaria, n. sp.

Pal. O., Vol. III, Plate 11, Figs. 11 and 12.

Shell small, none of the specimens observed exceeding three-eighths of an inch in diameter; sub-circular in outline, or varied in form by the outline of the object to which they are attached. Free valve depressed convex, marked by a few concentric lines of growth ; attached valve thin, but with a slightly thickened margin. Posterior muscular impressions large and sub-marginal, the others being nearly central and forming a small elevation just posterior to the middle of the valve.

The shells of this species are found attached to the spines of *Zeacrinus* and other bodies, one of those figured being upon the operculum of *Naticopsis*. They are very thin, and not easily detected in the roughened condition caused by the adhering material in which most of the fossils from these beds are found. Species of this genus are rather rare in the Coal-measures, but very few having been described. *Crania Permiana*, Shumard, from the white limestones of the Guadalupe Mts., Texas, is a large form, and probably not a *Crania*, according to the description given. *C. modesta*, White and St. John, from the Coal-

measures of Iowa, is described as "rather small, finely punctate, smooth, except somewhat strong concentric lines of growth toward the margins. Upper valve moderately convex, umbo oblique, nearly central. Lower valve moderately concave." There would appear to be some similarity between the upper valves of this and the Ohio species; but the remark concerning the lower valve being "moderately concave" throws considerable doubt on their identity, as the lower valve of this species is attached over its entire surface, while that one would appear to be free or partially free, if it is a *Crania*.

Formation and Locality.—In the Coal-measures of Carbon Hill, Hocking Co., Ohio. Collected by H. Moores, Esq., of Columbus, Ohio.

GASTEROPODA.

Naticopsis Ortoni, n. sp.

Pal. O., Vol. III, Plate 12, Figs. 12 and 13.

Shell small, with a somewhat depressed conical spire, which forms an angle of about 105 degrees, and the two and a half to three volutions are obliquely flattened on their upper side, in the direction of the spire; the outer one being marked just below the suture by a barely perceptible concave channel of considerable width, which produces a very slight angularity of the upper part of the volution. Suture-line slightly grooved. Lower side of the volution rounded; umbilicus closed; callus slight; aperture obliquely ovate at the outer margin, but rounded within from the excessive thickening of the shell. Surface of the shell marked by fine, rather equal and somewhat regular transverse striæ of growth, most distinctly marked on the lower half of the volution. On the outer half of the last volution, there occur lines of nodes, very faintly indicated, having a direction opposite to the growth-lines, and becoming fainter and finally imperceptible toward the lower side.

The species resembles *N. nana*, M. & W. (Geol. Rept. Ills., Vol. III, p. 365, pl. 32, fig. 4), in size and general form, but differs from it in the greater flattening of the volution in the direction of the spire, and in the faintly nodose surface.

Formation and Locality.—In a thin cherty band of the Coal-measures in the railroad cutting at Mrs. Banks' farm, Falls Township, Hocking Co., Ohio.

Loxonema plicatum, n. sp.

Pal. O., Vol. III, Plate 11, Figs. 14 and 19.

Shell small and slender, spire elevated, presenting an apical angle of about fifteen degrees; composed of about eleven volutions, in the example used and illustrated, which are flattened on the surface in the direction of the spire, and marked by strong vertical plicæ, which are directed a little forward in their passage across the volution from above downward. The body or largest volution, counting from the lip backward, contains fifteen of these plications, and the volutions above contain nearly the same number; those of the several volutions being in line with those on the one below, but set enough back of it to be in line with the slope of the plication. This gives them a somewhat spiral arrangement on the shell, the whole having a twist of about one-fourth of one turn in the length of the shell. On the last volution the plicæ are not distinct much below the bulge of the whorl. Aperture elongate and pointed below. Suture distinct, but not grooved or banded. Columella straight, about half as long as the aperture, solid, and terebra-like: shell without umbilicus.

The species belongs to a group of the genus which has but few representatives in our Coal-measures; and even those that are nearest allied to it appear to differ in the form of the columella, which is somewhat peculiar; and if other species should appear presenting these same characters, it may be necessary to separate them generically from the true *Loxonema.*

Formation and Locality.—In the Coal-measures of Carbon Hill, Hocking Co., Ohio. Collected by H. Moores, Esq.

CEPHALOPODA.

Nautilus Ortoni, n. sp.

Pal. O., Vol. III, Plate 12, Fig. 20.

Shell of medium size, and consisting of about two and a half or three closely coiled volutions, but which are not at all embracing; the outer one being simply in close contact with the medio-dorsal portion of the next within, and exposing nearly the entire dorso-ventral diameter of the shell. Volutions transversely sub-pentangular, being angularly convex on the back, strongly sub-angular on the sides, and concave on the abrupt umbilical slope, which forms a somewhat sigmoidal curve resembling an ogee moulding, while the slightly concave ventral surface is quite narrow, and forms a fifth surface. Lateral angles obtuse or round sub-angular, and ornamented by a series of nodes which are strong and very distinct on the inner coil, broad and rounded on the first part of the last volution, and become obsolete on the outer third. The substance of the shell has been very thick and strong, and the surface shows no evidence of growth-markings or striæ. Septa and other internal features unknown.

The shell resembles somewhat *N. spectabilis,* M. and W., but has a smaller number of coils in a shell of corresponding size, while the concavity of the umbilical slope and the sub-angular back are strong distinguishing features.

Formation and Locality.—In the Coal-measures at Springfield, Summit Co., Ohio. Cabinet of the School of Mines, N. Y. City.

Nautilus (Gyroceras?) subquadrangularis, n. sp.

Pal. O., III, Plate 11, Fig. 16.

Shell of about a medium size, consisting of two volutions, as seen on the specimen used, which increase somewhat rapidly in size with increased length, and are closely coiled so as to bring them in close contact, but not to be in any degree embracing. The inner volution, however, is coiled in so large a circle that it leaves an opening within it of about one inch in diameter. The shell is at first circular in section, but before the completion of the first coil the form has become modified so as to produce a sub-quadrangular section, narrowest on the dorsal side, and the second volution becomes distinctly quadrangular, being nearly as wide on the dorsum as across the lateral face; but the angles are all distinctly rounded, and the inner or umbilical margins most particularly so. The inner part of the shell has a line of strong node-like undulations on each dorsal angle, which become obsolete at about the first third of the second volution. Margin of the aperture greatly extended on the sides beyond the line of the inner edge, and apparently sinuate on the back. Septa deeply concave and numerous; those at the base of the outer chamber showing about three chambers in the space of one inch, and gradually decreasing in distance toward the earlier part of the shell. On the quadrangular parts, they are deeply receding on the sides and back, and correspondingly advanced on the angles ; a consequence of the quadrangular form on a deeply concave septum. Surface of the shell apparently smooth and the substance thin. Siphon unknown.

The species is peculiar in its quadrangular form, and in the wide opening through the centre; in these characters it differs from any previously described species. It is of a form that is with difficulty placed in the genus *Nautilus,*—its characters, so far as the external features are concerned, nearly resembling those of *Gyroceras,*—and in the absence of a knowledge of the position of the siphuncle, must remain doubtful.

Formation and Locality.—In limestone of the Coal-measures, at Canfield, Ohio. Collected by H. C. Bowman, and now in the cabinet of the School of Mines, New York City.

APPENDIX.

Leiorhynchus Newberryi.

Leiorhynchus Newberryi, H. & W., 23d Rept. State Cab., N. Y. In the description of this species it is correctly referred to the Chemung group, but improperly to the Waverley group on the plate.

Genus **Pholadella,** H. & W.

Preliminary notice of Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung groups, etc. (State Cab. Nat. Hist., Decem., 1869, p. 63). The name ("Hall, n. g.") incorrectly inserted without my knowledge.—R. P. W.

Pholadella Newberryi.

Pholadella, Newberryi, H. & W. Prelim. Notice, cited above, p. 65. *Allorisma* (*Sedgwickia ?*) *pleuropistha,* Meek; Pal. Ohio, Vol. I, p. 309, Plate 13,

Figs. 4*a* and 4*b*.

Pleurotomaria Mississippiensis.

Pleurotomaria Mississippiensis, White & Whitf., Proc. Bost. Soc. Nat. Hist., 1862, p. 203, Vol. 8.

Pleurotomaria textiligera, Meek ; Pal. Ohio, Vol. I, p. 314, Pl. 13, Figs. 7*a* and *b*.

Note on the Marcellus Shale and other Members of the Hamilton Group in Ohio, as determined from Palæontological Evidence.

During the early summer of 1878, Pres't Edward Orton wrote, asking if I could spend a few days with him in central and southern Ohio, in an effort to ascertain from palæontological evidence, the true horizon of certain layers of rock which had been somewhat of a difficulty to him; and in the month of August I spent several days with him for that purpose. While making

these somewhat hurried observations at a locality about six miles N. W. of Columbus, in Perry township, on the east bank of the Scioto River, we accidentally discovered a thin bed of dark brown shale, somewhat fissile and bituminous in character, in what Prof. Orton had considered as a representative of the Delaware limestone of Delaware, Ohio. The peculiar texture of the shales, occurring where I had expected only a light-colored limestone, excited my interest; and after a few minutes' examination, I discovered that they contain numerous flattened shells of *Leiorhynchus limitaris*, Vanuxem. I also obtained from them two specimens of *Discina minuta*, and examples of *Lingula Manni*, Hall; the two former being well-known and characteristic forms of the Marcellus shales of New York. On examination, we found that these shells, especially the *Leiorhynchus*, extended through a thickness of several feet of the rock, and that the peculiar bituminous character of the shale accompanied them, but with intercalations of thin layers of less bituminous and lighter-colored limestones. Subsequently, at a point nearly opposite Dublin, Ohio, some miles north of the above-mentioned locality, the same shale was again recognized in a corresponding horizon, accompanied by the same species, the *Leiorhynchus* being quite numerous. At a subsequent visit, Mr. Edward Hyatt obtained *Discina Lodensis*, Hall, another New York Marcellus species. At this second locality, immediately above the shale, and while the limestone layers retain much of the bituminous character, the layers become thicker and more calcareous, and their surfaces are covered with the shells of *Spirifera gregaria*, Clapp, and *Tentaculites scalariformis*, Hall, both of which are likewise common in the blue limestone layers at Delaware, Ohio.

A section of the rocks at the first-mentioned locality, six miles N. W. of Columbus, on the east bank of the Scioto, subsequently furnished by Prof. Orton, is as follows :

The lower bed, No. 1 of section, is a heavy-bedded limestone, about thirty feet thick, representing the Columbus quarries, including the coral beds and those containing the large cephalopods. (Lower Corniferous of the Ohio Geol. Rept.)

No. 2, a thin layer of limestone, four to six inches thick,

densely filled with teeth, plates and bones of fishes, locally known as the "Bone-bed."

No. 3, about thirty feet of thin-bedded shaly limestone, the "Delaware bed" of Prof. Orton. The upper part of this is supposed to represent the beds of similar character at Delaware, Ohio, which contain the large fish-remains.

No. 4, about fifteen feet of bluish, somewhat marly shales, the "Olentangy shales" of N. H. Winchell. This is followed above by the Huron shales, the supposed equivalents of the Genesee slates and Portage shales of New York.

Near the lower part of No. 3, only a few feet above the "Bone-bed," occurs the dark brown shale in question, with the peculiar fossils, which I have no hesitation in pronouncing the equivalent of the Marcellus shales of New York.. Admitting this—and there certainly appears to be no alternative—the rocks found above this limit should represent the Hamilton group of the New York system; and we ought to find some fossils here, characteristic of that formation, which would not pass below this line. To ascertain if this was so, I requested Mr. Edward Hyatt, who has collected carefully the fossils around Columbus, to furnish me a list* of the species known, with their horizons indicated; and also requested the use of specimens of species not known to occur below the horizon of the "Bone-bed,"—that being the most easily recognized limit, and the one most generally studied in connection with the vertical distribution. Contrary to my expectations, the species yet known not to pass below the "Bone-bed" are very few. These, with the exception of the *Tentaculites scalariformis*, have been illustrated on Plate 7, and are, with two exceptions, known Marcellus and Hamilton types,—one being a new species, and the other (*Spirifera Maia*, Bill.) occurring in the Upper Helderberg limestone in Canada. The examination of the upper layers for characteristic fossils was not carried far enough to make it perfect, owing to Mr. Hyatt's absence from Columbus; but the few forms found above these bituminous layers will readily be recognized as characteristic of the Hamilton group, and warrant one in considering the

* These lists will be found appended at the end of the present article.

Black Shales and other beds coming above these thin limestones in central Ohio, as equivalent to the Genesee Slates and succeeding formations of New York.*

The following lists, prepared by E. and H. Hyatt, of Columbus, Ohio, are from the limestones within 24 miles of that place. Those of the first list are from below the horizon of the "Bone-bed," and the next from above; *Strophomena rhomboidalis* being the only species fully recognized from both horizons. All species have been collected by them from known horizons, or have been seen from the beds by myself.

Species from below the "Bone-bed."

PROTOZOA.

Stromatopora, De Blainville.

C. granulosa, Nich.
S. nodulata, Nich.
S. ponderosa, Nich.
S. Sanduskyensis, Rominger.
S. substriatella, Nich.

Cannopora, Phillips.

C. columnaris, Nich.
C. densa, Nich.

Receptaculites, De France.

R. Devonicus, Whitf.

RADIATA.

Favosites, Lamarck.

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* Since writing the above remarks, Vol. 5 of the Palæont. of New York has been published. In it the author has, on page 139, some remarks on the limestones at the Falls of the Ohio, and their relations to the Hamilton group of New York. After showing that the Hydraulic-cement beds of the Falls of the Ohio are the equivalents of the Hamilton group of New York (which had already been stated in the Geol. Rept. Ind., 1875, pp. 147, 148, and also shown in sections on page 157), the author remarks, "In the State of Ohio, similar conditions may be inferred, from the fact that certain known species of Hamilton fossils are published in the Ohio Geological Reports as from the Corniferous group." At the meeting of the Am. Assoc. for the Advancement of Science, at Saratoga, August 1879, I read a notice of the occurrence in Ohio of rocks representing the Marcellus shales of New York, in which it was shown that a considerable thickness of the limestones previously recognized as "Corniferous" in Ohio, were above the horizon of the beds which I had recognized, from palæontological and lithological evidence, as of the age of the Marcellus shale, and would be of necessity equivalents of the Hamilton group.

F. basaltica, Goldf.
F. Gothlandica, Lamarck. (?)
F. hemispherica, Yand. and Shumard.
F. invaginata, Nich.
F. pleurodictyoides, Nich.
F. polymorpha, Goldf. ?
F. turbinata, Billings.

MICHELINA, De Koninck.
M. convexa, Emmons.
M. maxima, Troost.

EMMONSIA, Ed. and Haime.
E. Emmonsi, Hall.

TRACHYPORA, Ed. and Haime.
T. elegantula, Billings.

AULOPORA, Goldfuss.
A. cornuta, Bill.
A. filiformis, Bill.
A. tubæformis, Gold. ?

SYRINGOPORA, Goldf. ?
S. Hesingeri, Bill.
S. Maclurei, Bill.
S. tabulata, Ed. and Haime.

ERIDOPHYLLUM, Ed. and Haime.
E. Simcoense, Bill.
E. strictum, E. and H.
E. Verneuilanum, E. and H.

STYLASTREA, Lonsdale.
S. Annae, Whitf.

ZAPHRENTIS, Rafinesque.
Z. cornicula, Ed. and H.
Z. Edwardsi, Nich.
Z. gigantea, Ed. and H.
Z. prolifica, Bill.
Z. Wortheni, Nich.

CYATHOPHYLLUM, Goldf.
C. rugosum, Hall.
C. Zenkeri, Bill.

HADRIOPHYLLUM, Ed. and H.
H. D'Orbignyi, Ed. and H.

HELIOPHYLLUM, Ed. and H.
H. confluens, Hall.
H. Halli, Ed. and H.
AULACOPHYLLUM, Ed. and H.
A. sulcatum, Ed. and H.
CYSTIPHYLLUM, Lonsdale.
C. Americanum, Ed. and H.
C. Ohioense, Nich.
CRINOIDEA.
MEGISTOCRINUS, O. and S.
M. spinulosus, Lyon.
DOLATOCRINUS, Lyon.
D. multiradiatus, Hall.
D. radiatus, Hall.
BLASTOIDEA.
NUCLEOCRINUS Conrad.
N. Verneuili, Troost.
CODASTER, McCoy.
C. pyramidatus, Shumard.
ANCYROCRINUS, Hall.
A. spinosus, Hall.
MOLLUSCA.
BRYOZOA, Emmerich.
STICTOPORA, Hall.
S. Gilberti, Meek.
LICHENALIA, Hall.
L. lichenoides, Meek.
BRACHIOPODA.
DISCINA, Lamarck.
D. grandis, Vanux.?
CRANIA, Retzius.
C. crenistriata, Hall.
C. Hamiltoniae, Hall.
ORTHIS, Dalman.
O. Livia, Bill.
O. propinqua, Hall.
O. Vanuxemi, Hall.
STREPTORHYNCHUS, King.
S. flabellum, Whitf.

S. Pandora, Bill.

STROPHODONTA, Hall.

S. ampla, Hall.

S. demissa, Conrad.

S. hemispherica, Hall.

S. inequiradiata, Hall.

S. nacrea, Hall.

S. Patersoni, Hall.

S. perplana, Conrad.

S. subdemissa, Hall. ? ?

STROPHOMENA, Rafinesque.

S. rhomboidalis, Wilck.

CHONETES, Fischer.

C. acutiradiata, Hall.

C. arcuata, Hall.

C. deflecta, Hall.

C. mucronata, Hall. ?

C. Yandellana, Hall.

PRODUCTELLA, Hall.

P. spinulicosta, Hall.

SPIRIFERA, Sowerby.

S. acuminata, Con.

S. duodenaria, Hall.

S. euryteines, Owen.

S. fimbriata, Con.

S. gregaria, Clapp.

S. Greeri, Hall.

S. macra, Hall.

S. macrothyris, Hall.

S. Manni, Hall.

S. Marcyi, Hall.

S. Oweni, Hall.

S. segmenta, Hall.

S. varicosa, Hall.

SPIRIFERINA, D'Orb.

S. raricosta, (Conrad.)

CYRTINA, Davidson.

C. Hamiltoniæ, Hall.

MERISTELLA, Hall.

M. nasuta, (Conrad.)
M. scitula, (Hall.)
NUCLEOSPIRA, Hall.
N. concinna, Hall.
ATRYPA, Dalman.
A. reticularis, Linn.
RHYNCHONELLA, Fischer.
R. Billingsi, Hall.
R. Carolina, Hall.
R. Dotis, Hall.
R. Thetis, Billings.
R.? raricosta, Whitf.
PENTAMERELLA, Hall.
P. arata, Hall.
TEREBRATULA, Schlotheim.
T. Sullivanti, Hall.
TROPIDOLEPTUS, Hall.
T. carinatus, Conrad.

LAMELLIBRANCHIATA.

AVICULOPECTEN, McCoy.
A. crassicostata, H. and W.
A. paralis, Conrad.
PTERINEA, Goldf.
P. flabella, Conrad? The specimens referred to this species are very doubtfully identified. They are large coarse forms, very unlike any of those in the higher beds.
MYTILARCA, H. and W.
M. ponderosa, H. and W.
M. percarinata, Whitf.
CONOCARDIUM, Brown.
C. trigonale, Hall. *C. Ohioense*, Meek, is the young of the above.
GONIOPHORA, Phillips.
G. perangulata, H. and W.
PARACYCLAS, Hall.
P. lirata, Conrad.
P. occidentalis, H. and W. *P. Ohioensis*, Meek, is the same as *P. lirata*, Conrad.

MODIOMORPHA, H. and W.
M. elliptica?
M. perovata, Meek.
SANGUINOLITES, McCoy.
S. Sanduskyensis, Meek.
GASTEROPODA.
PLATYCERAS, Conrad.
P. attenuatum, Meek.
P. bucculentum, Hall.
P. carinatum, Hall.
P. conicum, Hall.
P. dumosum, Conrad.
P. multispinosum, Meek.
P. squalodens, Whitf.
PLATYOSTOMA, Conrad.
P. lichas, Hall.
EUOMPHALUS, Sowerby.
E. Decewi, Billings.
HOLOPEA, Hall.
H. rotundata, Hall, sp.
TURBO, Klein?
T. Kearneyi, Hall.
T. Shumardana, Yandell.
ISONEMA, M. and W.
I. bellatula, Hall.
I. depressa, H. and W.
I. humilis, Meek.
XENOPHORA, Fischer.
X. antiqua, Meek.
NATICOPSIS, McCoy.
N. æquistriata, Meek.
N. cretacea, H. and W.
N. levis, Meek.
LOXONEMA, Phillips.
L. Leda, Hall.
L. Hamiltoniæ, Hall.
L. parvulum, Whitf.
L. pexatum, Hall.
ORTHONEMA, M. and W.

O. Newberryi, Meek.
MACROCHEILUS, Phillips.
M. priscus, Whitf.
PLEUROTOMARIA, De France.
P. adjutor, Hall.
P. Doris, Hall.
P. Hebe, Hall.
P. Lucina, Hall.
MURCHISONIA, De Verneuil.
M. desiderata, Hall.
M. Maia, Hall.
M. obsoleta, Hall.
DENTALIUM, Linnæus.
D. Martini, Whitf.
BELLEROPHON, Montfort.
B. Newberryi, Meek.
B. Pelops, Hall.
B. propinqua, Meek.
PTEROPODA.
CONULARIA, Miller.
C. elegantula, Meek.
TENTACULITES, Schloth.
T. scicula, Hall.
CEPHALOPODA.
ORTHOCERAS, Breynius.
O. nuntium, Hall.
O. Ohioense, Hall.
O. profundum, Hall.
TREMATOCERAS, Whitf.
T. Ohioense, Whitf.
GOMPHOCERAS, Sowerby.
G. amphora, Whitf.
G. eximium, Hall.
G. Hyatti, Whitf.
G. Sciotense, Whitf.
CYRTOCERAS, Goldfuss.
C. cretaceum, Whitf.
C. Ohioense, Meek.
C. undulatum, Vanuxem ?

GYROCERAS, Meyer.

G. Columbiense, Whitf.

G. Cyclops, Hall.

G. inelegans, Meek.

G. Ohioense, Meek.

G. seminodosum, Whitf.

CRUSTACEA.

DALMANIA, Emmerich.

D. Calypso, Hall.

D. Helena, Hall.=*D. Ohioense*, Meek.

D. selenurus, Green.

PHACOPS, Emmerich.

P. rana, Green.

PROETUS, Steininger.

P. crassimarginatus, Hall.

Species from above the Bone-Bed.

———o———

CRINOIDEA.

GONIASTEROIDOCRINUS, Lyon.

G. spinigera, Hall.

BRACHIOPODA.

LINGULA, Brugiere.

L. Manni, Hall.

L. ligea, Hall.

DISCINA, Lamarck.

D. Lodensis, Hall.

D. minuta, Hall.

STROPHOMENA, Rafinesque.

S. rhomboidalis, Wilck.

CHONETES, Fischer.

C. scitula, Hall.

C. reversa, Whitf.

SPIRIFERA, Sowerby.

S. Maia, Billings.

S. zic-zac, Hall.

LEIORHYNCHUS, Hall.

L. limitaris, Vanuxem.

LAMELLIBRANCHIATA.

AVICULOPECTEN, McCoy.

A. equilatera, Hall.

PTERINEA, Goldfuss.

P. similis, Whitf.

ACTINODESMA, Sandberger.

A. subrecta, Whitf.

GRAMMYSIA, De Vern.

G. bisulcata, Conrad.

NYASSA, H. and W.

N. arguta, H. and W.

---o---

[NOTE TO PAGE 216.]

Genus **NYASSA,** H. and W.

Nyassa, H. & W., Prelim. Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung Groups, &c. Albany, Dec., 1869, p. 28,

Shells bivalve, very oblique and transversely ovate in form. Posterior hinge-plate narrow, bearing from one to four long slender ridge-like teeth. Anterior plate broad, marked by numerous small point-like teeth with intermediate depressions, arranged somewhat radiating from the middle of its inner border. Adductor muscles two, one at each extremity. Pallial line entire. Ligament internal. Type, *N. arguta.* Name, mythological. Geological range, so far as known, Devonian. Family relations apparently near *Megalomus,* Hall, and *Megalodon,* Sowerby.

Description of a New Species of Swift of the Genus Chætura, with Notes on two other little-known Birds.

BY GEORGE N. LAWRENCE.

Read February 6th, 1882.

Chætura Gaumeri, sp. nov.

Male.—Entire crown, hind neck and back of a smoky brownish-black; rump and upper tail-coverts dark ash, each feather narrowly bordered at the end with gray; tail-feathers ashy-brown; lores deep black; "iris brown;" throat whitish-gray; breast and upper part of abdomen dark smoky ash; the lower part of the latter and the under tail-coverts are of a darker shade; wings black, the under wing-coverts and the inner margins of the quills are of a dark ashy-brown; bill and feet black.

Length, about 4¼ inches; wing, 4¼; tail, 1¼, the spines wanting.

Habitat, Yucatan. Type in my collection. Obtained by Mr. Geo. F. Gaumer, in compliment to whom I have named it.

Mr. Gaumer spent three years in Yucatan; he made large collections in ornithology and other branches of natural history. A full series of his birds was purchased by the University of Kansas, and it is to be hoped that a catalogue of them will be published.

Mr. Gaumer wrote me that he had taken full notes of all the species, which he expected to publish when the names of those sold to the University of Kansas were determined. I purchased the remnant of his collection, in which were the birds now described.

In my list of birds from Yucatan (Ann. N. Y. Lyceum, Vol. IX, p. 204), I referred a specimen of swift to *C. Vauxi*, though noticing that it was smaller; now I find it to agree exactly with the bird above described. This comparison I have been enabled to make, by Mr. Ridgway's kindness in lending me the specimen, and sending besides all in the National Museum that are labelled as *C. Vauxi*.

At the time of my examination of the specimen from Yucatan belonging to the Smithsonian, the examples of *C. Vauxi* accessible were in poor condition; but since then, fine specimens of it have been received from California, by the National Museum as well as by myself. A comparison with these shows the Yucatan bird to be quite distinct.

Among those sent me from Washington, is one specimen from Guatemala (Duenas), collected by Mr. Salvin, Feb. 6th, 1860, and labelled by him as *C. Vauxi*, also one from Mexico (Tehuantepec), collected by Prof. Sumichrast, which I referred to *C. Vauxi* (Bull. U. S. Nat. Mus., No. 4, p. 32). Both are a little darker than those from Yucatan, but I consider that they are the same. These two specimens have the spines of the tail-feathers in perfect condition, whereas in the two from Yucatan, the spines are worn off close to the tail-feathers; this abrasion is caused, probably, by their inhabiting rocky cliffs.

This species differs from *C. Vauxi* in the much darker coloring of its upper and under plumage, though in that of the throat they are closely alike; it is a little smaller, and the wings and tail are shorter than in *C. Vauxi*. It has the upper plumage blacker even than that of *C. pelasgica*, but in that species the under plumage is darker.

Notes on PYRANGA ROSEIGULARIS, Cabot, *and* CENTURUS RUBRIVENTRIS, Swainson.

Pyranga roseigularis.

For a long time this species has been known only by the type, a male, in the collection of its discoverer, Dr. Cabot, of Boston. The acquisition of both sexes is therefore a fortunate occurrence.

Mr. Ridgway has given an accurate description of it (N. Amer. Birds, Vol. I, p. 434) taken from the type. The male I have, differs only in having a decided white superciliary stripe bordering the red crown.

The male measures in length $6\frac{3}{8}$ inches; wing, $3\frac{1}{8}$; tail, $2\frac{3}{4}$; tarsus, $\frac{3}{4}$.

I give a description of the female, as I think it has not been known heretofore.

The female has the upper and under plumage of the same general colors as the male; the crown and throat are washed with red; under tail-coverts pale reddish salmon-color; tail-feathers brown above, edged with light red; the under surface of the tail is paler in color and tinged with red; quills dark umber-brown, margined with light greenish yellow; upper wing-coverts of a rather dull olive-green; under wing-coverts pale yellow; upper mandible dark brown, the under whitish horn-color; tarsi and toes dark brown.

Length (skin), $6\frac{1}{8}$ inches; wing, 3; tail, $2\frac{3}{4}$; tarsus, $\frac{3}{4}$.

Centurus rubriventris.

The validity of this species seems generally to be questioned, and specimens of it have been but rarely obtained; therefore I was pleased to see another, a female, as it confirmed the opinion expressed by me in my Yucatan list (Ann. N. Y. Lyceum, Vol. IX, p. 206), that I considered it a valid species. Therein I described the male, and pointed out how it differed from *C. tricolor*, to which species it has been referred.

A comparison of the female with specimens of the same sex of *C. tricolor*, shows the differences to be equally as great as those of the males.

FEMALE.—The upper plumage, tertiaries and wing-coverts are black, narrowly barred with white; rump and upper tail-coverts white; tail-feathers black, the ends of the outer ones narrowly margined with white, and the outer edges of the lateral feathers indented with white; head light brownish-ash, on the crown hoary, front, chin, and sides of the head to a line with the middle of the eye, orange-yellow; on the hind neck there is a narrow band of vermilion; under parts brownish ash, with the middle of the abdomen vermilion; flanks barred with black and white; rather dull in color; under tail coverts gray, marked centrally with black, bill black and narrow; tarsi and toes black; "iris black."

Length (skin), $6\frac{1}{2}$ inches; wing, $4\frac{1}{8}$; tail, $2\frac{3}{4}$; bill, 11-16.

Besides differences of marking in the plumage, as shown in the Yucatan list, the bill and feet are much smaller than those of *C. tricolor*. Of this last species, I have several specimens of both sexes.

In Proc. U. S. Nat. Museum, 1881, p. 93, Mr. Ridgway gives "A Review of the Genus Centurus." Unfortunately the male specimen, noted in my Yucatan list, could not be found in the Nat. Museum collection; therefore an expression of his opinion from an autoptical examination was not possible.

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XV.—*The Parallel Drift-Hills of Western New York.*

BY LAURENCE JOHNSON.

Read January 9th, 1882.

That part of New York State which lies between Lake Ontario on the north, and Cayuga and Seneca lakes on the south, presents, in its surface geology, some features of exceptional interest.

The surface rocks of this region are, for the most part, deeply covered with drift, which is arranged in a series of parallel hills. Having been reared among these hills, my attention was early directed to their peculiar character; but, until recently, I had never attempted their systematic study. During the past two or three seasons, however, I have been enabled to renew my acquaintance with the region, and to study it more carefully; the result of my study and observation I now present as a slight contribution to our knowledge of drift phenomena.

Though the surface rocks are generally covered with drift, they are sufficiently exposed in a number of localities to furnish all the data necessary to a correct understanding of their characters and relative positions.

The lowest rock found in place in this region is the Medina sandstone. This occupies a narrow belt of territory along the shore of Lake Ontario, probably from one to two or three miles in width. In the vicinity of Big Sodus Bay, and also about Port Bay, it lies at or below the level of Ontario, while it rises toward the east and west, appearing at Oswego Falls, twenty-five miles east, and at the lower falls of the Genesee, fifty miles west, fully one hundred feet higher. I invite particular attention to this fact, for, as will appear later, I believe it to be a significant one.

Above the Medina sandstone rises the Clinton group, and upon this rests the Niagara, with no well-marked line dividing them. The Clinton is composed of thin-bedded limestones, shales, sandstones, and, in some places, thin beds of argillaceous iron ore. Owing to its lithological character, it has not exerted a very powerful influence upon the present topographical features of the region. Not so, however, is it with the overlying Niagara. The lower member of this group, here as further west, comprises thin-bedded, impure limestones and about eighty feet of shale; while the upper member is a mass of heavy-bedded, compact limestone. The geological position of this limestone, dividing as it does the great mass of soft rocks beneath from the still softer Salina shales above, has made it an important agent in the production of the present topography of the region. Economically, it is of importance to the inhabitants as the source from which they obtain lime.

There are no data for determining the exact width of the tract of which the Niagara is the surface rock, since its junction with the next succeeding group is nowhere apparent; it is, however, probably from two to five miles wide.

Along Wolcott Creek, the best nearly continuous exposure of the Clinton and Niagara, both together occupy the surface for five or six miles. Like the Medina on which they rest, they rise both east and west.

Upon the Niagara rests the Salina group, forming the surface rock all the way to Cayuga and Seneca lakes. The shales of this group are exposed in numerous places, especially along the valley of the Clyde and Seneca rivers, in railway cuttings, and in excavations for the Erie Canal. In two localities in this valley, namely, in a railway-cutting two miles west of Savannah, and in a hillside three or four miles southeast of Lyons, I have observed the upper, water-lime, layers of this group, in place.

With the Salina group, ends the succession of surface rocks of the region occupied by the parallel drift-hills. Above and to the south are, however, rocks which have exerted a marked causative influence upon the topography, not only of this region, but of that of the whole Ontario basin.

Passing the Water-lime and Oriskany sandstone, with the mere mention of their names, for they are of little importance here,

we come to the Upper Helderberg group. Like the upper member of the Niagara group, the Upper Helderberg is composed of compact, heavy-bedded limestone, and, like the Niagara, also, it forms the dividing line between much softer rocks—the Salina below and the Hamilton shales above. The position which it occupies is delineated on the map with, certainly, an approximation to accuracy.

Passing westward from Onondaga Valley, we find it, or should find it, if not concealed by drift, presenting a continuous escarpment as far as Cayuga Lake. West of Cayuga it reappears, and continues to Seneca Lake; and west of Seneca Lake it is continuous to the Genesee River. We observe, however, that the line of this escarpment is not straight. It bends several miles to the south when approaching Cayuga Lake, turns to the north a like distance after passing Seneca Lake, and then continues on a nearly straight line to the west. At its first exposure on the line running north from Seneca Lake, it presents a steep escarpment facing the east.

Above the Upper Helderberg rise the shales of the Hamilton group, estimated by Professor Hall to be 1,000 feet thick on Seneca Lake. To these succeed the Tully limestone, Genesee slate, Portage and Chemung groups, which form the great mountain ridge between the Catskill Mountains and Lake Erie.

In the Hamilton shales are excavated the greater part of the rock basins occupied by Skaneateles, Otisco, Owasco, Cayuga, Seneca and Canandaigua lakes. The only lake of the series, lying above the horizon of the Hamilton group, is Crooked Lake; its basin is excavated in the Genesee slate and Portage group.

Having thus briefly reviewed the surface rocks of this region, we will now consider the drift which covers them.

As already remarked, this is arranged in parallel hills. Though these hills attain their most characteristic development in the region between Cayuga and Seneca lakes on the south, and Lake Ontario on the north, the same peculiar arrangement of the drift is noticeable eastward as far as the Oswego River, and even beyond that point; westward, it is not particularly noticeable beyond the western boundary of Wayne County.

The individual hills vary greatly in length, in breadth, in

height, and in the angles at which they rise from the intervening valleys; but however much they may differ in these respects, they substantially agree in their general north and south direction. Their deviations from this line are slight. In the western part of Wayne County, and in the northwestern part of Seneca, they bear a few degrees west, and in eastern Wayne and Cayuga, a few degrees east of north.

While some of them may be traced two or three miles, attaining altitudes of one hundred or two hundred feet above the intervening valleys, the greater number are both shorter and lower. The highest and longest ones are chiefly situated just south of the northern out-crop of the Niagara limestone, though some very high ones are found several miles further south, upon the Salina. In general, however, the further we recede from the Niagara outcrop, and the nearer we approach Cayuga and Seneca lakes, the lower are the hills. There is no regularity in their positions, for while some groups of them occupy several square miles of territory, with but narrow valleys intervening, in other localities, swampy valleys occur, a mile or more in width and several miles in length. In some instances, hills are literally piled upon hills, so that one great ridge is lined along its sides by a number of subordinate ridges. Many of them were originally very difficult to cultivate, on account of their steep declivities, but this feature is far less noticeable now than it was twenty-five years ago, for frequent plowing, and the washing of rains and melting snow, have wrought great changes in them since the forests were removed. This remark applies particularly to the northern hills; but those situated further south—several miles from the Niagara out-crop—have not improved in the same ratio; the reason of which will be apparent when we consider their composition. Again, when hills have steep declivities, these are, with very few exceptions, upon their east or west sides or at their north ends; they almost uniformly slope to the south gradually. The exceptions occur in hills which have undergone changes since the material of which they are formed was first deposited.

As already foreshadowed, the irregularity of the hills has its parallel in that of the valleys. The smaller ones are shallow depressions between low ridges which serve the purposes of drain-

age. These, of course, are parallel with the including ridges. The larger valleys are generally cup-shaped depressions in the drift, especially those south of the Niagara out-crop, through which the minor streams flow with a sluggish current. Many of these have an area of several square miles, and, at no very distant day, have been the basins of shallow lakes. A few lakes occupying such basins still remain, and are delineated upon the map. Crusoe Lake, in Wayne County, and Duck Lake, a few miles distant, in Cayuga, are examples. The former is situated in a marsh, and is almost unapproachable; the latter lies between parallel ridges, with tamarack swamps extending north and south from its extremities, indicating its former limits, and foreshadowing its future obliteration. Indeed, in this region, the presence of tamarack in a swampy valley indicates that there was once a lakelet. All such valleys are cup-shaped, and so far as I have observed, the lip of the cup is composed of drift, and all have been filled to the brim with vegetable matter in the form of muck or peat.

The Niagara limestone forms the water-shed which divides the small streams that flow directly to Lake Ontario, from those flowing southward to the river which courses along a valley in the Salina. As shown by the map, this one stream has several names. As Mud Creek, it unites with the Canandaigua outlet to form Clyde River. Clyde River unites with the outlet of Cayuga and Seneca lakes, at Montezuma, where the stream takes the name of Seneca River. This flows in a general easterly course, gathering the waters of Owasco, Skaneateles and Onondaga lakes, until it unites with the outlet of Oneida, when it becomes the Oswego, and pursues a northwest course to Lake Ontario. Even this, now, after flowing for ages in its present channel, curiously exhibits the cup-shaped character of the north and south valleys, across which it makes its way in a general easterly course.

Throughout Wayne County it is remarkably tortuous, as exhibited by the map, but not account of meandering through a plain, as is often the case with crooked streams. On the contrary, in many places its current is moderately rapid, and many of its crooks and turns were made in finding its way eastward through ranges of north and south hills. Though nowhere ex-

posing rock in Wayne County, or in western Cayuga, its course is obstructed in several places by bars of boulders remaining from the drift which it has cut away. Examples may be seen between Lyons and Clyde, and at the latter village; another, further east, will be alluded to presently. Along this river valley are a few of the hills previously mentioned as exceptional, having steep southern declivities, evidently due, in a measure, to the erosive action of the river. One section of this river valley deserves our particular attention—that stretching from the foot of Cayuga Lake to the hills in the southern part of Wayne County. It comprises more than forty thousand acres of marsh lands, through which the Seneca pursues a northerly course by an almost imperceptible current. Indeed, so slight is the fall, that in times of flood the great volume of water brought down by the Clyde flows south as well as north, and has even discolored Cayuga Lake as far south as Springport. At such times, many of the smaller valleys are filled with back-water, particularly that in which lies Crusoe Lake; and Cayuga virtually extends to within a dozen miles of Ontario. That it did so extend in reality, at no very distant day, becomes evident when we examine the marsh. This is underlaid throughout its whole extent by several feet of shell marl, composed of the shells of existing species of *Unio, Planorbis, Physa, Limnæa,* etc.

Furthermore, upon the borders of the marsh, at Montezuma and in the southern part of the town of Savannah, are found salt springs rising from beneath the marl in a manner precisely similar to those of Salina. As is well-known, these latter rise from beneath a layer of shell marl underlying Onondaga Lake, and overlying from four to six hundred feet of gravel, which fills an ancient excavation, and serves as a reservoir for the brine.

Beds of sand, showing wave-action, also fringe the marsh in numerous localities.

The region for some distance north of Seneca Lake is also generally low and level, and is drained by slow and sluggish streams. Swamps are numerous and extensive, and not unfrequently enclose shallow lakes and ponds. Skirting this low-lying region are also beds and hills of sand, showing wave-action

like those about the Montezuma marsh, but, as will be shown later, laid down at an earlier period.

Just east of the northern termination of the marsh, at Mosquito Point, is the brim of this great cup-shaped valley. Here occurs a bar, through which the State has caused a channel to be cut, in order to drain the marshes. The excavation was made in *drift material.* That the bar was formerly much more extensive than in our days, is very evident. The finer materials were washed away, but the boulders resisted the erosive action of the moderate current, and formed an effectual dam.

A few miles further down the river, an artificial channel was cut to avoid another bar; the excavation was made in the Salina shales. Altogether, vast sums of money were expended, with the effect of improving the marshes, though without reclaiming them. Nor does it seem possible that this could be accomplished without cutting a channel northward directly toward Ontario.

We will now consider the materials which enter into the composition of the drift deposits of this region.

First, as to the surface. This is strewn more or less thickly with rounded boulders of all sizes, up to three and even four feet in diameter—the smaller ones, in some localities, being so very abundant as seriously to interfere with cultivation of the land, while the larger ones are comparatively few, and widely scattered. In general, the boulders are most abundant along the line of the out-cropping Niagara; and here there are many angular blocks of limestone, also; while further south they progressively diminish in numbers, and well down upon the Salina the surface is comparatively free from stones. These boulders, so far as I have observed, are of Niagara, Clinton, Medina, Hudson River, and the crystalline rocks—the latter including nearly all the larger ones. All the fossiliferous boulders are readily recognized by their lithological character, or by their fossils, which may be found in abundance in any stone wall, or other collection of stones in the region. I have found surface boulders apparently of Calciferous and Trenton, but the fossils of the former were too imperfect for satisfactory determination, and the latter may have come from limestone layers of the Hudson River group.

From numerous observations upon recently cleared lands, I should judge the relative proportions of the different rocks represented to be as follows: Medina, crystalline, Hudson River, Niagara, Clinton.

The surface soil of the upland along the Niagara outcrop, and for some distance south, is commonly of sandy loam, with boulders freely interspersed. Far down upon the Salina, and north toward Ontario, it is clayey. The soil of the valleys is of course much more variable, depending greatly upon the extent to which it has received the wash of the neighboring hills. All the swampy valleys have superficial deposits of muck or peat, while many, somewhat better drained, contain beds of brick-clay.

The surface soil of the uplands is from a few inches to a foot or two in thickness. Underneath, and separated from it by no well-defined line, is a deposit of far different character. This is a compact, tough, generally red, clay, filled with small glaciated pebbles and boulders. South of the Niagara outcrop, the included pebbles and boulders are almost entirely of the dark-blue hard Niagara limestone, while north of this line they are of lower rocks. In this clay, are no evidences of true stratification, though examples of a rude assortment of its materials are not uncommon. Some of these have been afforded in sinking wells. One case occurs to my mind, of two wells having about the same depth, a few rods apart, tapping the same reservoir, so that in dry times the upper may be drained by pumping out the lower. In this instance, the water-bearing layer is a coarse black sand, quite unlike the overlying clay, and was struck about twenty feet below the surface.

Numerous springs occurring on the hillsides also attest the rude assortment of these drift materials; for where the clay occurs in its typical character, it is almost as impervious to water as a rock.

This clay, with its included stones, is, in short, a typical boulder clay or till. Though I have described it as found in the uplands, excavations in the valleys show it in precisely the same character, though of course its superficial covering is quite different. An observation which I made last season will illustrate this point. After passing through two feet of muck, six inches of yellow sandy clay, six inches of washed gravel, and

eight inches of blue clay, the till was reached; and the first shovelful of earth, coming from below the blue clay, contained a small sub-angular boulder of blue limestone, covered with striæ almost as fresh as if made yesterday. Less than half a mile down this same valley, which is cup-shaped, and even now supports a growth of tamarack, the muck and peat were sounded with a pole to the depth of fifteen feet without finding solid bottom, and a quarter of a mile further south, in a cutting made to drain the swamp, the boulder clay was seen.

Instances might be multiplied of sections observed in ditches through uplands and lowlands, in cuttings for roads, etc., all showing the till in the same general character, however different may be the surface deposits.

We have here, then, two different kinds of drift deposits, the superficial and the deep. It remains to consider how they were placed in their present positions.

When the geological survey of New York was made, more than forty years ago, the peculiar arrangement of the drift in this region was noted, and the opinion was expressed that the materials were deposited by streams of running water (Report of the 4th Dist., Hall). Since that time, other writers have expressed a like opinion with various modifications. Some have supposed that a broad sheet of glacial drift has suffered aqueous erosion; in other words, that the valleys have been cut by streams, and that the steep northern declivities of the hills are proof that the streams flowed toward the south.

That the first explanation is insufficient, in the present state of geological science, is evident at a glance. Running waters do not deposit unmodified boulder clay, such as we have shown this to be.

Examination will show the second explanation quite as unsatisfactory. The first objection is that the valleys are cup-shaped depressions in the drift; the second, that there is an entire absence of such accumulations of river gravel as must have remained had a broad sheet of glacial drift been cut by streams. Either of these objections is fatal to the theory.

From the evidence which I have presented, I think but one conclusion can be reached, namely that the drift was deposited here in nearly its present form by a glacier, at least, all its *deeper*

portion. As to the superficial layer, including the larger crystalline boulders, we cannot be so certain.

But conceding that it was deposited by glacial action, we have still to account for its peculiar topographical features. Such extensive deposits of drift are, perhaps, not very uncommon, but such peculiar regularity of deposition is certainly seldom met with, at least in this country. Sir William Logan has reported something similar in Canada, and as will be shown presently, a parallel is found in Scotland.

That this great drift deposit cannot be classed with terminal or lateral moraines, is evident at once from its general composition, for it differs from them in almost every essential particular. It must of necessity be termed the *moraine profonde,*—the ground moraine.

Why it came to assume its present shape, instead of that of a broad sheet of nearly uniform thickness, will, I think, become evident when we consider the points from which the glacier forming it came, and the forces which influenced that glacier's flow in this locality.

In a recently published article Professor Hitchcock says, "The latest generalizations indicate that some part of the Labrador Peninsula may be considered as the center from which the ice has radiated over the Dominion of Canada and the northern United States, east of the Rocky Mountains * * * * * most of this territory exhibits a southwesterly course of glaciation * * * well shown over the highlands between Hudson's Bay and the St. Lawrence Valley, the valley itself, western New York" etc.; "while in eastern New York and the Champlain and Hudson Valleys, the course is southerly."

Professor Newberry, in an article on the Surface Geology of Ohio, presents a very interesting and satisfactory general summary of the glacial phenomena throughout the whole lake region. He believes that the period opened with the formation of local glaciers on the Laurentian Mountains, which crept down and began the excavation of the present lake basins in what was then the valley of a river which drained this portion of the continent, flowing through the present Mohawk Valley. That, as the cold increased, these local glaciers partially coalesced, forming a many-lobed ice-sheet, which moved radiatingly from

the southern, southwestern and western slopes of the Canadian highlands. To quote his own words : "The effect of this glacier upon Lake Erie and Lake Ontario, would be to broaden their basins by impinging against and grinding away, with inconceivable power, their southern margins. To the action of this agent we must ascribe the peculiar outline of the profile sections drawn from the Laurentian hills across the basin of Lake Ontario to the Alleghanies, and across Lake Erie to the highlands of Ohio, viz., a long, gradual slope from the north to the bottom of the depression, and then an abrupt ascent over the massive and immovable obstacle against which the ice was banked, until by a *vis a tergo,* it overtopped the barrier. In New York, that barrier was a shoulder of the Alleghanies, too high and too rugged to be buried under a continuous ice-sheet; but its whole front was worn away for a hundred miles or more, and it was deeply creased where we now see the peculiarly elongated lakes of New York, and cut through, in certain gaps, to the valley of the Delaware. In Ohio, the erosion was easier, and carried further south. The barrier was also lower, and was finally overtopped by one great lobe of ice, which flowed on to the south and west until its edge reached the Ohio River. * * * With the amelioration of the climate, the wide-spread ice-sheets of the period of intense cold became again local glaciers, which completed the already begun work of cutting out the lake basins. At first, the glacier which had before flowed over the water-shed in Ohio, was so far reduced as to be unable to overtop its summit, but deflected by it, it flowed along its base, spending its energies in cutting the shallow basin in which Lake Erie now lies.

"A further elevation of temperature curtailed the glacier still more, and Lake Erie became a water-basin, while local glaciers, left from the ice-sheet, excavated the basins of Lake Michigan, Lake Huron and Lake Ontario. The latter lake was apparently formed by the same glacier that made the Erie basin, but when much abbreviated. It flowed from the Laurentian hills and the north slope of the Adirondacks, and was deflected by the highlands south of the lake-basin, so that its motion was nearly westward." *

* Geological Survey of Ohio, Vol II, p. 78.

Though this summary is in general very satisfactory, the last statement, namely, that the local glacier which finished the excavation of the Ontario basin "was deflected by the highlands south of the lake-basin, so that its motion was nearly westward," if applied to the region which we are considering, would seem to require modification. The direction of these drift-ridges, together with their steep northern declivities, render it evident that the glacier which deposited them came from and retired to the north. Professor Newberry's remark might, however, be applied without change to the western portion of the Ontario basin, for in that locality there are no drift-ridges, showing a different direction of the ice-flow, while the course of the glacial striæ upon exposed rock-surfaces supports the view. These latter, unfortunately, are not accessible to any great extent in the region occupied by the drift-hills. I regret that I cannot offer their evidence in corroboration of that afforded by the hills. We have, however, what I conceive to be much more important testimony—the direction of the long axes of the chain of small lakes south of the hills. A glance at any map of New York will readily show that lines drawn through the long axes of Canandaigua, Seneca, Cayuga, Owasco and Skaneateles lakes, converge toward a point on the Canadian shore of Ontario. That these lake-basins were excavated by glacial action, seems almost self-evident, and is, indeed, almost universally admitted. Their radiated arrangement, in my opinion, admits of but one explanation, namely, that they were cut by one and the same great glacier, whose margin was broken into several streams in crossing the mountain ridge, and that this glacier flowed in a general southerly direction from the Canadian highlands. Furthermore, the maximum of its force was exerted along its central line, in the vicinity of Seneca and Cayuga lakes. Opposite these lakes the shore of Ontario is deeply indented by a number of bays, notably by Big Sodus. That the glacier occupied this region for an immensely long period of time, is evident from the great depth of the rock-basins of Cayuga and Seneca,—the former having now a depth of more than four hundred, and the latter of more than six hundred feet. As stated above, Cayuga formerly extended a dozen miles or more further north than now. Its buried basin has been sounded at Montezuma, in

borings for brine, and in driving piles for the canal aqueduct, to the depth of a hundred feet or more. Our estimate of the extent of glacial erosion in the vicinity of these lakes is, however, scarcely begun when we have sounded their depths, for more than a thousand feet of rock were removed before the present level of their waters was reached.

Attention has already been invited to the fact, that the Upper Helderberg escarpment bends several miles south in approaching Cayuga and Seneca lakes, and also to the indentation of the Ontario shore opposite the locality. Now this indentation of the Ontario shore is where the Medina sandstone is found at its lowest level. Taking these facts, together with that of the maximum of glacial erosion being found along the line where the exposed rocks are seen at their lowest levels, have we not an indication of the causes which influenced the ice-flow in this region ?

Glaciers, like water, at first follow the lines of lowest level. In the original topography of this region, previous to the ice period, there was a valley here—not a deep one, it is true, but deep enough to influence an ice-current. Evidence that this valley was not confined to the immediate shore of Ontario, is not wanting. Several miles south of Geneva, the outlet of Crooked Lake, in its easterly course to Seneca Lake, exhibits a fine section of the Portage group, Genesee slate, and Hamilton shales, all dipping to the east at a comparatively high angle.

I think we may safely assume that the pre-glacial drainage of this valley contributed not a little to fit it for the great ice-current which was to come. Indeed, it is generally conceded by geologists that the ancient excavation in which lies Onondaga Lake, is probably a buried pre-glacial river-channel; and some even suppose that this river drained Lake Ontario in a south-easterly direction—a supposition which is highly improbable. It is much more reasonable to assume that the pre-glacial drainage of this region was not far different from its present; and that the channel of the river where now lies Onondaga Lake, was not only deepened, but subsequently filled up by the glacial action, even as appears to have been the case with the north end of Cayuga Lake, to which allusion has already been made.

However this may be, it appears evident that when the ice

came, it moved up the shallow valley, described above, radiating to the east and west as it proceeded; and in the valley it remained until its final retreat to the north.

Under this ice were formed the parallel hills, in a manner which, so far as I know, has only been explained by Geikie, and in the following words: "In narrow and deep hollows, like the upland valleys, the ice was not liable to such deflections as took place over the 'debatable' grounds, and the till forming below it consequently escaped being squeezed to and fro; the valleys were filled with streams of ice flowing constantly in one and the same direction, and the probabilities are therefore strong that the débris which accumulated below would be spread out smoothly.

"In the lowlands the effect produced by the varying direction and unequal pressure of the ice-sheet is visible in the peculiar outline assumed by the till. Sometimes it forms a confused aggregate of softly-swelling mounds and hummocks; in other places it gives rise to a series of long smoothly-rounded banks or 'drums' and 'sow-backs,' which run parallel to the direction taken by the ice. This peculiar configuration of the till, although doubtless modified to some extent by rain and streams, yet was no doubt assumed under the ice-sheet,—the 'sow-backs' being the glacial counterparts of those broad banks of silt and sand that form here and there upon the beds of rivers.

"Perhaps the most admirable example in Scotland of this peculiar arrangement or configuration of the till occurs in the valley of the Tweed, between the Cheviot Hills and the Lammermuirs. In this wide district, all the ridges of till run parallel to each other, and in a direction approximately east and west. This, too, is the prevailing trend of the rock-striations and *roches moutonnées* in the same neighborhood." *

If our theory be correct, the region which we are considering must, indeed, have been "debatable," no less than some of the localities mentioned by Geikie, for it must have been the north and south line whence the ice was deflected both eastward and westward, and fluctuations of lateral pressure must have been both numerous and striking. Add to this the change of form assumed by the ice in passing from the broad basin of Ontario

* The Great Ice Age, by James Geikie, F. R. S. E., etc., p. 88. N. Y., 1874.

into the basins of the Cayuga and Seneca, where it swept between sloping walls of rock nearly 2000 feet in height, and we need not be surprised to find the drift in its present position and shape.

A curious and interesting effect of this change of form in the ice as it approached Cayuga and Seneca, is shown in the direction of the drift-hills in the northwestern part of Seneca County, viz. several degrees west of north, as if the lower part of the glacier which fashioned them had been forced by lateral pressure toward the lake valleys.

It remains to consider the question of how these hills escaped the changes, so commonly incident to the drift, during the melting of the glaciers.

As the ice had crept slowly down to the line which now marks its ancient termination, so did it slowly retire at the close of the glacial epoch. During its retreat from Pennsylvania to the highlands of New York, the water from its melting edge flowed freely away, and often sorted the drift materials, depositing them not unfrequently in a more or less stratified condition. When, however, the highlands were passed, the conditions changed, and a lake was formed whose southern shore was the mountain ridge, while its northern boundary was a wall of ice. Evidences of the southern shore-line are still apparent in certain ill-defined beaches, which were described by Professor Hall forty years ago, when they were much better marked than now; and its northwestern boundary is outlined by beaches in the vicinity of Toronto, several hundred feet above the present level of Ontario.

This lake undoubtedly discharged its waters southward through the valleys in which lie the small lakes of the mountain ridge. During this period, the parallel drift-hills were in deep water, and hence beyond the reach of denuding agencies, though they doubtless received the débris of melting icebergs, particularly the large boulders of crystalline rocks which here and there dot the surface, but are not present in the boulder clay.

As the melting progressed still further, the Mohawk Valley was probably opened, and the water sank below the line of the lowest pass of the highlands to the south—that of Seneca Lake, whose summit is now about nine hundred feet above sea-level. That the St. Lawrence valley was still closed with ice, is ren-

dered probable by the evidence we have that Lake Ontario stood for a long time at a point two hundred feet above its present level. This evidence is afforded by the old lake ridge, which, beginning near Big Sodus Bay, extends westward to and beyond the Niagara River, at a distance of from three to five miles from the lake. Its height, about two hundred feet above Ontario, is several feet above the summit level of the Mohawk Valley, while this latter has evidently been considerably silted up since Ontario ceased to discharge its waters in this direction. Moreover, that there was ice not far distant, while this lake ridge was being formed, is proved by the absence of fossils from the ridge itself, and from the heavy beds of clay deposited during the same period. Professor Hall did, indeed, report from hearsay evidence, the finding of shells in the ridge, but I am not aware that the report has been verified. The clays are, I am sure, barren of fossils.

The eastern terminus of the ridge is peculiarly interesting. As shown by the map, near Big Sodus Bay it turns to the southeast. It may be traced in this direction for two or three miles, and is then lost in the cultivated fields. Why is this?

As has been shown, the surface rocks of this region rise to the west of Sodus. Now, west of this point, the lake ridge is at about the level of the valleys in the drift, while eastward the valleys are deeper, and hence a continuous beach was impossible. The waters of the lake did, however, work great havoc with many of the larger hills, evidence of which fact is still apparent in the beds of sand and rounded pebbles about them, and of clay in the valleys. Naturally, such evidence is found near the present lake shore, since the first ranges of hills would break the force of the waves, and in a measure protect those further south. Again, the ranges of hills still further south, facing Cayuga and Seneca lakes, suffered denudation in the same manner and at the same times, though of course to a much less-marked extent. The beds of sand between Lyons and Geneva, and at numerous other points along the valley of the Clyde and Seneca rivers, were undoubtedly deposited at this period by wave-action. There was thus a belt between Ontario and Cayuga and Seneca lakes protected against wave-action; here we find the hills nearly as they were left by the glacier, and

as they have been described in this paper; and here, though there are some unimportant beds of clay, there are no beach sands.

The elevations above Ontario of a few localities, will enable us to form an idea of the general appearance of the region in those ancient times.

The signal-station of the New York State Survey, two miles south of Clyde, is upon a hill 388 feet above Ontario; that at Victory, seventeen miles distant, 323 feet, and the one at Gilbertsville, seventeen miles further east, 276 feet; the Clyde River at Clyde, 145 feet. Hence, when Ontario stood at the level of the old ridge, there were more than 50 feet of water in the Clyde, while the hills upon which stand the signal stations were islands from 75 to 200 feet above the lake. True, these hills are among the highest of the region, but there are scores of others nearly or quite as high, while all of the larger valleys are but little above that of the Clyde River. The one running north from Clyde village was many years ago surveyed for a canal, to connect the Erie with Big Sodus, but which failed of completion from financial, not engineering, difficulties. The valley stretching north from the Montezuma marshes to Wolcott was also surveyed, with a view to ascertaining the practicability of draining the marshes in this direction, and it was shown that a cutting of eighteen feet would effect the object.

Seneca Lake is 207 feet above Ontario; Cayuga, 131 feet; Onondaga, 118 feet; and the summit-level of the Erie Canal in the Mohawk Valley, 182 feet. The following are elevations along the line of the Ontario shore railroad: Hannibal, 93 feet; Sterling, 72 feet; Red Creek, 87 feet; Wolcott, 112 feet; Rose, 141 feet; Alton, 154 feet; Wallington, 160 feet; Sodus (near the lake ridge), 182 feet; and Ontario, 169 feet.

Along the immediate shore of the lake west of Big Sodus Bay, the elevation is not greater than 60 feet, while east of this point, a number of hills attain the altitude of 120 feet (Charts of the U. S. Lake Survey).

These figures, meagre as they are, present to the mind a graphic picture of this region when the waters of Ontario were raising the ancient beach. Every prominent hill of to-day was then an island, and every considerable valley a deep channel,

through which the waters circulated slowly toward the gate whence they were discharged from the lake-basin. The gate, we assume, for reasons already stated, to have been the Mohawk Valley.

During this period the ice was still retreating; and finally the St. Lawrence valley was opened. The waters then sank below the summit-level of the Mohawk, and have since flowed in their present channel.

This last change must have occurred with comparative rapidity, for the waters of Ontario sank so rapidly as to have formed no beach between the old Lake Ridge and its present level. Now, had this change been due, as is believed by many, to an elevation of the land, we might reasonably expect to find some intermediary beaches. That an elevation of land was in progress is not doubted; but that an elevation, continental in extent, should have occurred with such rapidity as to have produced the effects ascribed to it in the lake region, seems at least problematical; while the giving way of an ice-dam in the upper St. Lawrence valley presents no such difficulties.

During the progress of this final recession of the waters of Ontario, the drift in the region of the parallel hills suffered considerable erosion, evidences of which are found in the river valleys, and in the gorges of the small streams leading into the bays along the lake shore. Naturally, the valley of the Oswego River exhibits the best evidences attainable of the erosion of this period. Here are found heavy beds of sand and gravel, far above the present channel, to mark the rush of those ancient waters.

NOTE.

In the compilation of the accompanying map, the writer has to acknowledge his indebtedness to the charts of the U. S. Lake Survey, the preliminary maps of the New York State Survey, the Geological Survey of New York, the Geological Railway Guide, by James MacFarlane, Ph. D.; Mr. O. S. Wilson, Assistant in Charge, N. Y. State Survey; and Mr. E. A. Doane, Chief Engineer, R., W., & O. R. R.

His thanks are also due to Prof. R. P. Whitfield, Curator of the Geological Department of the American Museum of Natural History, for the determination of fossils, and for much other valuable assistance.

XVI.—*The Origin and Relations of the Carbon Minerals.*

BY J. S. NEWBERRY.

Read February 6th, 1882.

What are called the carbon minerals,—peat, lignite, coal, graphite, asphalt, petroleum, etc.,—are, properly speaking, not minerals at all, as they are organic substances, and have no definite chemical composition or crystalline forms. They are, in fact, chiefly the products or phases of a progressive and inevitable change in plant-tissue, which, like all organic matter, is an unstable compound and destined to decomposition.

In virtue of a mysterious and inscrutable force which resides in the microscopic embryo of the seed, a tree begins its growth. For a brief interval, this growth is maintained by the prepared food stored in the cotyledons, and this suffices to produce and to bring into functional activity some root-fibrils below and leaves above, with which the independent and self-sustained life of the individual begins. Henceforward, perhaps for a thousand years, this life goes on, active in summer and dormant in winter, absorbing the sunlight as a motive power, which it controls and guides Its instruments are the discriminating cells at the extremities of the root-fibrils, which search for, select and absorb the crude aliment adapted to the needs of the plant to which they belong, and the chlorophyll cells—the lungs and stomach of the tree—in the leaves. During all the years of the growth of the plant, these organs are mainly occupied in breaking the strongly rivetted bonds that unite oxygen and carbon in carbonic acid; appropriating the carbon and drawing off most of the oxygen. In the end, if the tree is, *e. g.*, a *Sequoia,* some hundreds of tons of solid organized tissue have been raised into a

column hundreds of feet in height, in opposition to the force of gravitation, and to the affinities of inorganic chemistry.

The time comes, however, sooner or later, when the power which has created and the life that has pervaded this wonderful structure, abandon it. The affinities of inorganic chemistry immediately reassert themselves; in ordinary circumstances rapidly tearing down the ephemeral fabric.

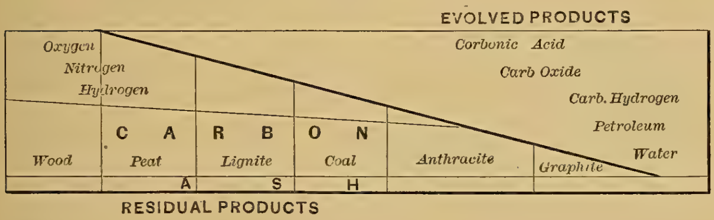
The disintegration of organic tissue, when deserted by the force which has animated and preserved it, gives rise to the phenomena which form the theme of this paper.

Most animal tissue decomposes with great rapidity, and plant-tissue, when not protected, soon decays. This decay is essentially oxidation, since its final result is the restoration to the atmosphere of carbonic acid, which is broken up in plant-growth by the appropriation of its carbon. Hence it is a kind of combustion, although this term is more generally applied to very rapid oxidation with the evolution of sensible light and heat. But whether the process goes on rapidly or slowly, the same force is evolved that is absorbed in the growth of plant-tissue; and by accelerating and guiding its evolution, we are able to utilize this force in the production at will of heat, light, and their correlatives, chemical affinity, motive power, electricity and magnetism. The decomposition of plants may, however, be more or less retarded, and it then takes the form of a destructive distillation; the constituents reacting upon each other, and forming temporary combinations, part of which are evolved, and part remain behind. Water is the great extinguisher of this as of the more rapid oxidation that we call combustion; and the decomposition of plant-tissue under water is extremely slow, from the partial exclusion of oxygen. Buried under thick and nearly impervious masses of clay, where the exclusion of oxygen is still more nearly complete, the decomposition is so far retarded that plant-tissue, which is destroyed by combustion almost instantaneously, and if exposed to "the elements,"—moisture with a free access of oxygen,—decays in a year or two, may be but partially consumed when millions of years have passed. The final result is, however, inevitable, and always the same, viz., the oxidation and escape of the organic matter, and the concentration of the inorganic matter woven into its com-

position,—in it, but not of it,—forming what we call the ash of the plant.

Since the decomposition of organic matter commences the instant it is abandoned by the creative and conservative vital force, and proceeds uninterruptedly, whether slowly or rapidly, to the final result, it is evident that each moment in the progress of this decomposition presents us with a phase of structure and composition different from that which preceded and from that which follows it. Hence the succession of these phases forms a complete sliding scale, which is graphically shown in the following diagram, where the organic constituents of plant-tissue—carbon, hydrogen, oxygen, and nitrogen—appear gradually diminishing to extinction, while the ash remains nearly constant, but relatively increasing, till it is the sole representative of the fabric.

DIAGRAM SHOWING THE GENETIC RELATIONS OF THE CARBON MINERALS.



We may cut this triangle of residual products where we please, and by careful analysis determine accurately the chemical composition of a section at this point, and we may please ourselves with the illusion, as many chemists have done, that the definite proportions found represent the formula of a specific compound; but an adjacent section above or below would show a different composition, and so in the entire triangle we should find an infinite series of formulæ, or rather no constant formulæ at all. We should also find that the slice, taken at any point while lying in the laboratory or undergoing chemical treatment, would change in composition, and become a different substance.

In the same way we can snatch a brand from the fire at any stage of its decomposition, or analyze a decaying tree-trunk during any month of its existence, and thus manufacture

as many chemical formulæ as we like, and give them specific names; but it is evident that this is child's play, not science. The truth is, the slowly decomposing tissue of the plants of past ages has given us a series of phases which we have grouped under distinct names, and we have called one group peat, one lignite, another coal, another anthracite, and another graphite. We have spaced off the scale, and called all within certain lines by a common name; but this does not give us a common composition for all the material within these lines. Hence we see that any effort to define or describe coal, lignite or anthracite, accurately, must be a failure, because neither has a fixed composition, neither is a distinct substance, but simply a conventional group of substances which form part of an infinite and indivisible series.

But this sliding scale of solid compounds, which we designate by the names given above, is not the only product of the natural and spontaneous distillation of plant-tissue. Part of the original organic mass remains, though constantly wasting, to represent it; another part escapes, either completely oxidized as carbonic acid and water, or in a volatile or liquid form, still retaining its organic character, and destined to future oxidation, known as carburetted hydrogen, olefiant gas, petroleum, etc.

Hence, in the decomposition of vegetable tissue, two classes of resultant compounds are formed, one residual and the other evolved; and the genesis and relation of the carbon minerals may be accurately shown by the following diagram.

PLANT-TISSUE.

Residual Products.	Evolved Products.	
Peat.		
Lignite.		
Bituminous Coal.	Carbonic Acid.	
Semi-bituminous Coal.	Carbonic Oxide.	
Anthracite.	Carburetted Hydrogen, etc.	
Graphitic Anthracite.	Water.	
Graphite.	Petroleum.	Maltha.
Ash.		Asphalt, etc.
		Asphaltic Coal.
		Asphaltic Anthracite.

[NOTE.—In this diagram, the vertical line connecting the names of the residual products (and of the derivatives of petroleum) indicates that each succeeding one is produced by further alteration from that which precedes it, and not independently. Also, the arrangement of the braces is designed to show that any or all of the evolved products are given off at each stage of alteration.]

The theory here proposed has not been evolved from my inner consciousness, but has grown from careful study, through many years, of facts in the field. A brief sketch of the evidence in favor of it is all that we have space for here.

RESIDUAL PRODUCTS.

Peat.—Dry plant-tissue consists of about 50 per cent. of carbon, 44 per cent. of oxygen, with a little nitrogen, and 6 per cent. of hydrogen. In a peat-bog, we find the upper part of the scale represented above very well shown ; plants are growing on the surface with the normal composition of cellulose. The first stratum of peat consists of browned and partially decomposed plant-tissue, which is found to have lost perhaps 20 per cent. of the components of wood, and to have acquired an increasing percentage of carbon. As we descend in the peat, it becomes more homogeneous and darker, until at the bottom of the marsh, ten or twenty feet from the surface, we have a black carbonaceous paste which, when dried, resembles some varieties of coal, and approaches them in composition. It has lost half the substance of the original plant, and shows a marked increase in the relative proportion of carbon.

Lignite.—Each inch in vertical thickness of the peat-bog represents a phase in the progressive change from wood-tissue to lignite, using this term with its common signification, to indicate, not necessarily carbonized ligneous tissue, but plant-tissue that belongs to a past though modern geological age ; *i. e.*, Tertiary, Cretaceous, Jurassic, or Triassic. These lignites or modern coals are only peat-beds which have been buried for a longer or shorter time under clay, sand or solidified rock, and have progressed farther or less far on the road to coal. As with peats, so

with lignites, we find that at different geological levels they exhibit different stages of this distillation—the Tertiary lignites being usually distinguished without difficulty by the presence of a larger quantity of combined water and oxygen, and a less quantity of carbon, than the Cretaceous coals, and these in turn differ in the same respects from the Triassic.

All the coals of the Tertiary and Mesozoic ages are grouped under one name ; but it is evident that they are as different from each other as the new and spongy from the old and well-rotted peat in the peat-bog.

Coal.—By mere convention, we call the peat which accumulated in the Carboniferous age by the name of bituminous coal ; and an examination of the Carboniferous strata in different countries has shown that the peat-beds formed in the Carboniferous age, though varying somewhat, like others, with the kind of vegetation from which they were derived, have a common character by which they may be distinguished from the more modern coals ; containing less water, less oxygen, and more carbon, and usually exhibiting the property of coking, which is rare in coals of later date. Though there is great diversity in the Carboniferous coals, and it would be absurd to express their composition by a single formula, it may be said that, over the whole world, these coals have characteristics, as a group, by which they can be recognized, the result of the slow decomposition of the tissue of plants which lived in the Carboniferous age, and which have, by a broad and general change approximated to a certain phase in the spontaneous distillation of plant-tissue. An experienced geologist will not fail to refer to their proper horizon a group of coals of Carboniferous age, any more than those of the Cretaceous or Tertiary.

Anthracite.—In the ages anterior to the Carboniferous, the quantity of land vegetation was apparently not sufficient to form thick and extensive beds of peat; but the remains of plant-tissue are contained in all the older formations, though there only as anthracite or graphite—the last two groups of residual products. Of these we have examples in the beds of graphite in the Laurentian rocks of Canada, and of anthracite of the Lower Silurian strata of Upper Church and Kilnaleck, Ireland.

From these facts it is apparent that the carbon series is graded geologically, that is, by the lapse of time during which plant-tissue has been subjected to this natural and spontaneous distillation. But we have better evidence than this, of the derivation of one from another of the groups of residual products which have been enumerated. In many localities, the coals and lignites of different ages have been exposed to local influences—such as the outbursts of trap-rock, or the metamorphism of mountain chains,—which have hastened the distillation, and out of known earlier groups have produced the last. For example, trap outbursts have converted Tertiary lignites in Alaska into good bituminous coals; on Queen Charlotte's Island, on Anthracite Creek, in southwestern Colorado, and at the Placer Mountains near Santa Fè, New Mexico, Cretaceous lignites into anthracite; those from Queen Charlotte's Island and southwestern Colorado, are as bright, hard and valuable as any from Pennsylvania. At a little distance from the focus of volcanic action, the Cretaceous coals of southwestern Colorado have been made bituminous and coking, while at the Placer Mountains the same stratum may be seen in its anthracitic and lignitic stages.

A still better series, illustrating the derivation of one form of carbon solids from another, is furnished by the coals of Ohio, Pennsylvania and Rhode Island. These are of the same age; in Ohio, presenting the normal composition and physical characters of bituminous coals, that is, of plant-tissue generally, and uniformly descending the scale in the lapse of time from the Carboniferous age to the present. In the mountains of Pennsylvania the same coal-beds, somewhat affected by the metamorphism which all the rocks of the Alleghanies have shared, have reached the stage of *semi-bituminous* coals, where half the volatile constituents have been driven off; again, in the anthracite basins of eastern Pennsylvania, the distillation further effected has formed from these coals *anthracite*, containing only from three to ten per cent. of volatile matter; while in the focus of metamorphic action, at Newport, Rhode Island, the Carboniferous coals have been changed to *graphitic anthracite*, that is, are half anthracite and half graphite. Here, traveling from west to east, a progressive change is noted, similar to that

which may be observed in making a vertical section of a peat-bog, or in comparing the coals of Tertiary, Mesozoic and Carboniferous age, only the latter is the continuation and natural sequence of the former series of changes.

In the Laurentian rocks of Canada are large accumulations of carbonaceous matter, all of which is graphite, and that which is universally conceded to be derived from plant-tissue. The oxidation of graphite is artificially difficult, and in nature's laboratory slow; but it is inevitable, as we see in the decomposition of its outcrops and the blanching of exposed surfaces of clouded marbles, where the coloring is graphite. Thus the end is reached, and by observations in the field, the origin and relationship of the different carbon solids derived from organic tissue are demonstrated.

It only remains to be said, in regard to them, that all the changes enumerated may be imitated artificially, and that the stages of decomposition which we have designated by the names graphite, anthracite, coal, lignite, are not necessary results of the decomposition of plant-tissue. A fallen tree may slowly consume away, and all its carbonaceous matter be oxidized and dissipated without exhibiting the phases of lignite, coal, etc.; and lignite and coal, when exposed to air and moisture, are burned away to ashes in the same manner, simply because in these cases complete oxidation of the carbon takes place, particle by particle, and the mass is not affected as a whole in such a way as to assume the intermediate stages referred to. Chemical analysis, however, proves that the process is essentially the same, although the physical results are different.

Evolved Products.

The gradual wasting of plant-tissue in the formation of peat, lignite, coal, etc., may be estimated as averaging for peat 20 to 30 per cent.; lignite, 30 to 50 per cent.; coal, 50 to 70 per cent.; anthracite, 70 to 80; and graphite, 90 per cent. of the original mass. The evolved products ultimately represent the entire organic portion of the wood—the mineral matter, or ash, being the only residuum. These evolved products include both liquids and gases, and by subsequent changes, solids are pro-

duced from some of them. Carbonic acid, carbonic oxide, nitrogenous and hydro-carbon gases, water and petroleum, are mentioned above as the substances which escape from wood-tissue during its decomposition. That all these are eliminated in the decay of vegetable and animal structures, is now generally conceded by chemists and geologists, although there is a wide difference of opinion as to the nature of the process.

It has been claimed that the evolved products enumerated above are the results of the primary decomposition of organic matter, and never of further changes in the residual products; *i. e.*, that in the breaking-up of organic tissue, variable quantities of coal, anthracite, petroleum, marsh-gas, etc., are formed, but that these are never derived the one from the other. This opinion is, however, certainly erroneous, and the formation of any or all the evolved products may take place throughout the entire progress of the decomposition. Marsh-gas and carbonic acid are seen escaping from the surface of pools where recent vegetable matter is submerged, and they are also eliminated in the further decomposition of peat, lignite, coal and carbonaceous shale. Fire-damp and choke-damp, common names for the gases mentioned above, are produced in large quantities in the mines where Tertiary or Cretaceous lignites, or Carboniferous coals or anthracites are mined. It has been said that these gases are simply locked up in the interstices of the carbonaceous matter, and are liberated in its excavation; but all who have worked coal-mines know that such accumulations are not sufficient to supply the enormous and continuous flow which comes from all parts of the mass penetrated. We have ample proof, moreover, that coal, when exposed to the air, undergoes a kind of distillation, in which the evolution of carbonic acid and hydro-carbon gases is a necessary and prominent feature.

The gas-makers know, that if their coal is permitted to lie for months or years after being mined, it suffers serious deterioration, yielding a less and less quantity of illuminating gas with the lapse of time. So coking coals are rendered dry, non-caking, and valueless for this purpose, by long exposure.

Carburetted hydrogen, olefiant gas, etc., are constant associates of the petroleum of springs or wells, and this escape of gas and oil has been going on in some localities, without apparent

diminution, for two or three thousand years. We can only account for the persistence of this flow by supposing that it is maintained by the gradual distillation of the carbonaceous masses with which such evolutions of gas or of liquid hydrocarbons are always connected. If it were true that carburetted hydrogen and petroleum are produced only from the primary decomposition of organic tissue, it would be inevitable that at least the elastic gases would have escaped long since.

Oil-wells which have been nominally exhausted—that is, from which the accumulations of centuries in rock reservoirs have been pumped—and therefore have been abandoned, have in all cases been found to be slowly replenished by a current and constant secretion, apparently the product of an unceasing distillation.

In the valley of the Cumberland, about Burkesville, one of the oil-regions of the country, the gases escaping from the equivalent of the Utica shale accumulate under the plates of impervious limestone above, until masses of rock and earth, hundreds of tons in weight, are sometimes thrown out with great violence. Unless these gases had been produced by comparatively recent distillation, such explosions could not occur.

In opening a coal-mine on a hillside, the first traces of the coal-seam are found in a dark stain in the superficial clay; then a substance like rotten wood is reached, from which all the volatile constituents have escaped. These appear, however, later, and continue to increase as the mine is deepened, until under water or a heavy covering of rock, the coal attains its normal physical and chemical characters. Here it is evident that the coal has undergone a long-continued distillation, which must have resulted in the constant production of carbonic acid and carburetted hydrogen.

A line of perennial oil and gas springs marks the outcrop of every great stratum of carbonaceous matter in the country. Of these, the most considerable and remarkable are the bituminous shales of the Silurian (Utica shale), of the Devonian (Hamilton and Huron shales), the Carboniferous, etc. Here the carbonaceous constituent (10 to 20 per cent.) is disseminated through a great proportion of inorganic material, clay and sand, and seems both from the nature of the materials which furnished it,—cellular plants and minute animal organisms,—and its dis-

semination, to be specially prone to spontaneous distillation. The Utica shale is the lowest of these great sheets of carbonaceous matter, and that supplies the hydro-carbon gases and liquids which issue from the earth at Collingwood, Canada, and in the valley of the Cumberland. The next carbonaceous sheet is formed by the great bituminous shale-beds of the Upper Devonian, which underlie and supply the oil-wells in western Pennsylvania. In some places the shale is several hundred feet in thickness, and contains more carbonaceous matter than all the overlying coal strata. The outcrop of this formation, from central New York to Tennessee, is conspicuously marked by gas-springs, the flow from which is apparently unfailing.

Petroleum is scarcely less constant in its connection with these carbonaceous rocks than carburetted hydrogen, and it only escapes notice from the little space it occupies. The two substances are so closely allied that they must have a common origin, and they are in fact generated simultaneously in thousands of localities.

During the oil excitement of some years since, when the whole country was hunted over for "oil-sign," in many lagoons, from which bubbles of marsh-gas were constantly escaping, films of genuine petroleum were often found on the surface; and as the underlying strata were barren of oil, this could only have been derived from the decaying vegetable tissue below. In the Bay of Marquette, two or three miles north of the town, where the shore is a peat-bog underlain by Archæan rocks, I have seen bubbles of carburetted hydrogen rising in great numbers, attended by drops of petroleum, which spread as iridescent films on the surface.

The remarks which have been made in regard to the heterogenous nature of the solid hydro-carbons, apply with scarcely less force to the gaseous and liquid products of vegetable decomposition. The gases which escape from marshes contain carbonic acid, a number of hydro-carbon gases (*or* the materials out of which they may be composed in the process of analysis), and finally a larger or smaller volume of nitrogenous gas. It is possible that the elimination of these gases takes the form of fractional distillation, and definite compounds may be formed directly from the wood-tissue or its derivatives, and mingle as

they escape. This is, however, not certain, for the gases, as we find them, are always mixtures and never pure. In the liquid evolved products, the petroleums, this is emphatically true, for we combine under this name fluids which vary greatly in both their physical and chemical characters; some are light and ethereal; others are thick and tarry; some are transparent, some opaque; some red, some brown, others green; some have an offensive and others an agreeable odor; some contain asphalt in large quantity, others paraffine, etc. Thus they form a heterogeneous assemblage of liquid hydro-carbons, of which naphtha and maltha may be said to form the extremes, and which have little in common, except their undefinable name. The causes of these differences are but imperfectly understood, but we know that they are in part dependent on the nature of the organic material that has furnished the petroleums, and in part upon influences affecting them after their formation. For example, the oil which saturates the Niagara limestone at Chicago, and which is undoubtedly indigenous in this rock, and probably of animal origin, is black and thick; that from Enniskillen, Canada, is also black, has a vile odor, probably in virtue of sulphur compounds, and we have reason to believe is derived from animal matter. The oils of northwestern Pennsylvania are mostly brown, sometimes green by reflected light, and have a pungent and characteristic odor. These are undoubtedly derived from the Hamilton shales, which contain ten or twenty per cent. of carbonaceous matter, apparently produced from the decomposition of sea-weeds, since these are in places exceedingly abundant, and nearly all other fossils are absent.

The oils of Italy, though varying much in appearance, have usually an ethereal odor that is rather agreeable; they are of Tertiary age. The oils of Japan, differing much among themselves, have as a common character an odor quite different from the Pennsylvania oils. So the petroleums of the Caspian, of India, California, etc., occuring at different geological horizons, exhibit a diversity of physical and chemical characters which may be fairly supposed to depend upon the material from which they have been distilled. The oils in the same region, however, are found to exhibit a series of differences which are plainly the

result of causes operating upon them after their production. Near the surface, they are thicker and darker; below, and near the carbonaceous mass from wh ch they have been generated, they are of lighter gravity and color. We find, in limited quantity, oils which are nearly white, and may be used in lamps without refining,—which have been refined, in fact, in nature's laboratory. Others, that are reddish yellow by transmitted light, sometimes green by reflected light, are called amber oils, these also occur in small quantity, and as I am led to believe, have acquired their characteristics by filtration through masses of sandstone. Whatever the variety of petroleum may be, if exposed for a long time to the air, it undergoes a spontaneous distillation, in which gases and vapors, existing or formed, escape, and solid residues are left. The nature of these solids varies with the petroleums from which they come, some producing asphaltum, others paraffine, others ozokerite, and so on through a long list of substances, which have received distinct names as mineral species, though rarely if ever possessing a definite and invariable composition. The change of petroleum to asphalt may be witnessed at a great number of localities. In Canada, the black asphaltic oil forms by its evaporation great sheets of hard or tarry asphalt, called gum-beds, around the oil-springs. In the far West, are numerous springs of petroleum, which are known to the hunters as "*tar-springs*," because of the accumulations about them of the products of the evaporation and oxidation of petroleum to tar or asphalt. Certain less common oils yield ozokerite as a solid, and considerable accumulations of this are known in Galicia and Utah.

Natural paraffine is less abundant, and yet in places it occurs in considerable quantity. Asphalt is the common name for the solid residue from the evaporation and oxidation of petroleum; and large accumulations of this substance are known in many parts of the world, perhaps the most noted of all being that of the "Pitch Lake" of the island of Trinidad;—there, as every where else, the derivation of asphalt from petroleum is obvious and traceable in all stages. The asphalts, then, have a common history in this, that they are produced by the evaporation and oxidation of petroleum. But it should also be said that they share the diversity of character of petroleums, and the term

asphalt represents a group of substances of which the physical characters and chemical composition differ greatly in virtue of their derivation, and also differ from changes which they are constantly undergoing. Thus at the Pitch Lake in Trinidad, the central portion is a tarry petroleum, near the sides a plastic asphalt, and finally that which is of almost rock-like solidity. Hence we see that the solid residues from petroleum are unstable compounds like the coals and lignites, and in virtue of their organic nature are constantly undergoing a series of changes of which the final term is combustion or oxidation. From these facts we might fairly infer that asphalts formed in geological ages anterior to the present would exhibit characters resulting from still further distillation; that they would be harder and drier, *i. e.*, containing less volatile ingredients, and more fixed carbon. Such is, in fact, the case; and these older asphalts are represented by *Grahamite*, *Albertite*, etc., which I have designated as asphaltic coals. These are found in fissures and cavities in rocks of various ages, which have been more or less disturbed, and usually in regions where springs of petroleum now exist. The Albertite fills fissures in Carboniferous rocks in New Brunswick, on a line of disturbance and near oil-springs. Precisely the same may be said of the Grahamite of West Virginia. It fills a vertical fissure, which was cut through the sandstones and shales of the Coal-measures; in the sandstones it remained open, in the shales it has been closed by the yielding of the rock. The Grahamite fills the open fissure in the sandstone and was plainly introduced when in a liquid state. In the vicinity are oil springs, and it is on an axis of disturbance. From near Tampico, Mexico, I have received a hydrocarbon solid—essentially Grahamite,—asphalt and petroleum. These are described as occurring near together, and evidently represent phases of different dates in the same substance. I have collected asphaltic coals, very similar to Grahamite and Albertite in appearance and chemical composition, in Colorado and Utah, where they occur with the same associates as at Tampico. I have found at Canajoharie, New York, in cavities in the lead-veins which cut the Utica shale, a hydro-carbon solid which must have infiltrated into these cavities as petroleum, but which, since the remote period, when the fissures were formed, has been distilled until it is now

anthracite.' Similar anthracitic asphalt or asphaltic anthracite is common in the Calciferous sand-rock in Herkimer County, New York, where it is associated with, and often contained in, the beautiful crystals of quartz for which the locality is famous. Here the same phase of distillation is reached as in the coke residuum of the petroleum stills.

Finally, in some crystalline limestones, detached scales or crystals of *graphite* occur, which are undoubtedly the product of the complete distillation of liquid hydro-carbons with which the rock was once impregnated. The remarkable purity of such graphite is the natural result of its mode of formation, and such cases resemble the occurrence of graphite in cast iron and basalt. The black clouds and bands which stain many otherwise white marbles are generally due to specks of graphite, the residue of hydro-carbons which once saturated the rock. Some limestones are quite black from the carbonaceous matter they contain (Lycoming Valley, Penn., Glenn's Falls, N. Y. and Collingwood, Canada), and these are sold as black marbles, but if exposed to heat, such limestones are blanched by the expulsion of the contained carbon; usually a residue of anthracite or graphite is left, forming dark spots or streaks, as we find in the clouded and banded marbles.

In the preceding remarks, no effort has been made even to enumerate all the so-called carbon minerals which have been described. This was unnecessary in a discussion of the relations of the more important groups, and would have extended this article much beyond its prescribed length. Those who care to gain a fuller knowledge of the different members of the various groups, are referred to the admirable chapter on the "Hydro-carbon Compounds" in Dana's Mineralogy.

It will however add to the value of this paper, if brief mention be made of a few carbon minerals of which the genesis and relations are not generally known, and in regard to which special interest is felt, such as the diamond, jet, and the hydro-carbon jellies, "Dopplerite," etc.

The diamond is found in the *debris* of metamorphic rocks in many countries, and is probably one of the evolved products of the distillation of organic matter they once contained. Under peculiar circumstances it has apparently been formed by precip-

itation from sulphide of carbon or some other volatile carbon compound by elective affinity. Laboratory experiments have proved the possibility of producing it by such a process, but the artificial crystals are microscopic, perhaps only because a long time is required to build up those of larger size.

Jet is a carbonaceous solid which in most cases is a true lignite, and generally contains more or less of the structure of wood. Masses are sometimes found, however, that show no structure, and these are probably formed from bitumen which has separated from the wood of which it once formed part, and which it generally saturates or invests. In some cases, however, these masses of jet-like substance are plainly the residuum of excrementitious matter voided by fishes or reptiles. These latter are often found in the Triassic fish-beds of Connecticut and New Jersey, and in the Cretaceous marls of the latter State.

The discovery of a quantity of hydro-carbon jelly, recently, in a peat-bed, at Scranton, Pa., has excited some wonder; but similar substances (Dopplerite, etc.) have been met with in the peat-beds of other countries; and while the history of the formation of this singular group of hydro-carbons is not yet well understood, and offers an interesting subject for future research, we have reason to believe that these jellies have been of common occurrence among the evolved products of the decomposition of vegetable tissue in all ages.

The generalities of the origin and relations of the carbon minerals have now been briefly considered; but a review of the subject would be quite incomplete without some reference to the theories which have been advanced by others, that are in conflict with the views now presented. There have always been some who denied the organic nature of the mineral hydro-carbons; but it has been regarded as a sufficient answer to their theories, that chemists are agreed in saying that no instances have come to the knowledge of man of the occurrence in nature of hydro-carbons, solid, liquid or gaseous, in which the evidence was not satisfactory that they had been derived from animal or vegetable tissue. A few exceptional cases, however, in which chemists and geologists of deserved distinction have claimed the possibility and even probability of the production of marsh gas, petroleum, etc., through inorganic agencies, require notice.

In a paper published in the *Annales de Chimie et de Physique*, Vol. IX. p. 481, M. Berthelot attempts to show that the formation of petroleum and carburetted hydrogen from inorganic substances is possible, if it is true, as suggested by Daubreé, that there are vast masses of the alkaline metals—potassium, sodium, etc.—deeply buried in the earth, and at a high temperature, to which carbonic acid should gain access; and he demonstrates that these premises being granted, the formation of hydro-carbons would necessarily follow.

But it should be said that no satisfactory evidence has ever been offered of the existence of zones or masses of the unoxidized alkaline metals in the earth, and it is not claimed by Berthelot that there are any facts in the occurrence of petroleum and carburetted hydrogen in nature which seem to exemplify the chemical action which he simply claims is theoretically possible. Berthelot also says that, in most cases, there can be no doubt of the organic origin of the hydro-carbons.

Mendeleeff, in the *Revue Scientifique*, 1877, p. 409, discusses at considerable length the genesis of petroleum, and attempts to sustain the view that it is of inorganic origin. His arguments and illustrations are chiefly drawn from the oil-wells of Pennsylvania and Canada, and for the petroleum of these two districts he claims an inorganic origin, because, as he says, there are no accumulations of organic matter below the horizons at which the oils and gases occur. He then goes into a lengthy discussion of the possible and probable source of petroleum, where, as in the instances cited, an organic origin "is not possible." It is a sufficient answer to M. Mendeleeff to say, that beneath the oil-bearing strata of western Pennsylvania are sheets of bituminous shale, from one hundred to five hundred feet in thickness, which afford an adequate, and it may be proven the true, source of the petroleum, and that no petroleum has been found below these shales; also, that the oil-fields of Canada are all underlain by the Collingwood shales, the equivalent of the Utica carbonaceous shales of New York, and that from the outcrops of these shales petroleum and hydro-carbon gases are constantly escaping. With a better knowledge of the geology of the districts he refers to, he would have seen that the facts in the cases he cites afford the strongest evidence of the organic origin of petroleum.

Among those who are agreed as to the organic origin of the hydro-carbons, there is yet some diversity of opinion in regard to the nature of the process by which they have been produced.

Prof. J. P. Lesley has at various times advocated the theory that petroleum is indigenous in the sand-rocks which hold it, and has been derived from plants buried in them. (Proc. Amer. Philos. Soc., Vol. X, pp. 33, 187, etc.)

My own observations do not sanction this view, as the number of plants buried in the sandstones of the Coal measures or the Conglomerate must always have borne a small proportion in volume to the mass of inorganic matter; and some of those which are saturated with petroleum are almost completely destitute of the impressions of plants.

In all cases where sandstones contain petroleum in quantity, I think it will be found that there are sheets of carbonaceous matter below, from which carburetted hydrogen and petroleum are constantly issuing. A more probable explanation of the occurrence of petroleum in the sandstones, is that they have, from their porosity, become convenient receptacles for that which flowed from some organic stratum below.

Dr. T. Sterry Hunt has regarded limestones, and and especially the Niagara and Corniferous, as the principal sources of our petroleum; but, as I have elsewhere suggested, no considerable flow of petroleum has ever been obtained from the Niagara limestone, though, as at Chicago and Niagara Falls, it contains a large quantity of bituminous matter; also, that the Corniferous limestone which Dr. Hunt has regarded as the source of the oil of Canada and Pennsylvania, is too thin, and too barren of petroleum, or the material out of which it is made, to justify the inference.

The Corniferous limestone is never more than fifty or sixty feet thick, and does not contain even one per cent. of hydrocarbons; and in southern Kentucky, where oil is produced in large quantity, this limestone does not exist.

That many limestones are more or less charged with petroleum is well-known; and in addition to those mentioned above, the Silurian limestone at Collingwood, Canada, may be cited as an example; and as I have elsewhere shown, we have reason to believe that the petroleum here is indigenous, and has been

derived in part, at least, from animal organisms; but the limestones are generally compact, and if cellular, their cavities are closed, and the amount of petroleum which, under any circumstances, flows from or can be extracted from limestone rock, is small. On the other hand, the bituminous shales which underlie the different oil regions, and are constantly associated with the flow of the petroleum and carburetted hydrogen, afford an abundant source of supply, holding the proper relations with the reservoirs that contain the oil, and are spontaneously and constantly evolving gas and oil, as may be observed in a great number of localities. For this reason, while confessing the occurrence of petroleum and asphaltum in many limestones, I am thoroughly convinced that little or none of the petroleum of commerce is derived from them.

Prof. S. F. Beckham, who has studied the petroleum field of Southern California, attributes the abundant hydro-carbon emanations in that locality to microscopic animals. It is quite possible that this is in part true in this and other localities; but the bituminous shales which are evidently the sources of the petroleum of Pennsylvania, Ohio, Kentucky, etc., generally contain abundant impressions of sea-weeds, and indeed these are almost the only organisms which have left any traces in them. I am inclined therefore now, as in my report on the Rock Oils of Ohio, published in 1860, to ascribe the carbonaceous matter of the bituminous shales of Pennsylvania and Ohio, and hence the petroleum derived from them, to the easily decomposed cellular tissue of algae which have in their decomposition contributed a large percentage of diffused carbonaceous matter to the sediments accumulating at the bottom of the water where they grew. In a recent communication to the National Academy of Sciences, Dr. T. Sterry Hunt has proposed the theory that anthracite is the result of the decomposition of vegetable tissue when buried in porous strata like sandstone; but an examination of even a few of the important deposits of anthracite in the world will show that no such relationship as he suggests obtains. Anthracite may and does occur in sedimentary rocks of varied character, but so far as my observation has extended, never in quantity in sandstone. In the Lower Silurian rocks anthracite occurs, both in the old world and in the new, where

no metamorphism has affected it and where it is simply the normal result of the *long continued* distillation of plant tissue, but the anthracite beds which are known and mined in so many countries are the results of the metamorphism of coal-beds of one or another age, by local outbursts of trap, or the steaming and baking of the disturbed strata in mountain chains—numerous instances of which are given on a preceding page.

Mr. M. Mendeleeff, in his article already referred to, misled by want of knowledge of the geology of our oil-fields, and ascribing the petroleum to an inorganic cause, connects the production of oil in Pennsylvania and Caucasia with the neighboring mountain chains of the Alleghanies and the Caucasus; but in all such localities, a sufficient amount of organic matter can be found to supply a source for the petroleum, while the upheaval and loosening of the strata along lines parallel with the axes of elevation in mountain chains has favored the decomposition (spontaneous distillation) of the carbonaceous strata. It should be distinctly stated, however, that no igneous rocks are found in the vicinity of productive oil-wells, here or elsewhere, and there are no facts to sustain the view that petroleum is a volcanic product.

In the valley of the Mississippi, in Ohio, Illinois and Kentucky, are great deposits of petroleum very far removed from any mountain-chain or volcanic vent, and the cases which have been cited of the limited production of hydro carbons in the vicinity of, and probably in connection with, volcanic centres, may be explained by supposing that in these cases the petroleum is distilled from sedimentary strata, containing organic matter affected by the proximity of melted rock or steam. Everything indicates that the distillation which produces the greatest quantities of petroleum known is effected at a low temperature, and the constant escape of petroleum and carburetted hydrogen from the outcrops of bituminous shales, as well as the result of weathering on the shales, depriving them of all their carbon, shows that the distillation and complete elemination of the organic matter they contain may take place at the ordinary temperature.

XVII.—*Descriptions of two New Species of Birds from Yucatan, of the Families Columbidæ and Formicariidæ.*

BY GEORGE N. LAWRENCE.

Read May 29th, 1882.

1. **Leptoptila fulviventris.**

Fore part of the head of a pale bluish white ; top of the head, back and wings, olive-brown; on the rump there is a slight greenish tinge ; the metallic color on the sides of the neck is light violet-red, changing to green on the hind neck ; the upper tail-coverts and central tail-feathers are colored like the back ; the outer tail-feather is blackish brown, ending with white on the inner web, and with light fulvous on the outer ; the next feather is similarly marked, and has the outer web of a lighter brown at the base, for a short distance ; the third feather has the outer web ruddy brown for two-thirds its length from the base, in other respects colored like the first and second feathers ; the fourth feather is brown for its entire length, except at the end, where it is fulvous white ; the primary and secondary quills are vandyke-brown, narrowly edged with pale fulvous white near their ends, tertials the color of the back ; the wing-coverts are of a warmer brown than the back; chin whitish; the sides of the head, the throat and the breast are of a rather dark reddish fawn-color ; the upper part and sides of the abdomen and the flanks are of a clear light fulvous ; the middle of the abdomen and the under tail-coverts are white, tinged with fulvous ; under wing-coverts and axillars deep reddish cinnamon ; the inner margins of the quills edged with very pale cinnamon ; bill black ; tarsus and toes dull fleshy brown, in the dried state.

Length (skin), $10\frac{1}{4}$ inches ; wing, $5\frac{1}{2}$; tail, $4\frac{1}{2}$; bill, $\frac{11}{16}$; tarsus, $\frac{3}{4}$.

Type in the museum of the State University of Kansas, at Lawrence, Kansas.

Remarks.—The color of the front is quite similar to that of *L. albifrons*, and it resembles that species somewhat in it coloring above, but is rather darker; the under plumage is quite different in coloration, and also much darker; the under wing-

coverts are of a lighter shade of cinnamon than in *albifrons;* the feet are strikingly smaller and more feeble than those of that species, and it is less in size.

2. Furnarius pallidus,

The upper plumage is of a clear pale ochreous brown, or light snuff-brown ; the top of the head is of a darker brown; the front has a tinge of rufous; the lores are white ; the rump and upper tail-coverts are light rufous ; the tail-feathers are light brown, blackish at their ends, which are edged with white ; inner webs of quills liver-brown, the outer colored like the back ; the wing-coverts and tertials are of a ruddy light brown ; the under wing-coverts are pale ochreous white, with blackish ends ; the under surfaces of the quills are light reddish ochraceous, for half their length from the base ; the throat and sides of the head are blackish ; the neck is encircled by a well defined collar of deep bright rufous, this color extending on the sides of the head behind the eye ; the upper part of the breast is of a light dull brownish cinereous ; upper part and sides of the abdomen of a lighter shade, more of a pale brown ; the middle of the abdomen is white, just tinged with ochreous ; under tail-coverts brown, with a wash of dull light-colored rufous ; bill black ; tarsi and toes pale brown.

Length (skin), $7\frac{1}{2}$ inches; wing, $3\frac{1}{2}$; tail, $2\frac{1}{2}$; tarsus, $1\frac{1}{4}$; bill from front, $\frac{7}{8}$.

Type in museum of the State University of Kansas.

Remarks.—This species is much paler in coloration than all others of the genus; in distribution of markings, it most resembles *F. moniliger*, but it is very much paler throughout, the red collar is more distinct than in that species, and the white spot in the lores is larger; the tail is brown instead of black, and the ochraceous coloring on the bases of the quill-feathers is twice the extent that it is in *F. moniliger;* it is also longer than that species in all its dimensions.

When describing a new swift from Yucatan (antea, p. 245), I alluded to the fact, that the State University of Kansas had purchased a full series of the birds obtained in that country by Mr. Geo. F. Gaumer.

Since then Prof. F. H. Snow of the University has sent me the collection for determination; besides the species above described, of which there is but one example of each, it contains many others of much interest.


A
GEOLOGICAL MAP
DESIGNED TO ILLUSTRATE A PAPER
ON THE
PARALLEL DRIFT-HILLS
OF
WESTERN NEW YORK
BY
DR. LAURENCE JOHNSON.
Elevations in feet, above Lake Ontario are indicated by numerals.
LAKE ONTARIO
245 feet above Sea level
HUDSON RIVER GROUP
MEDINA SANDSTONE
CLINTON GROUP
NIAGARA GROUP
SALINA GROUP
WATERLIME AND ORISKANY SANDSTONE
UPPER HELDERBERG GROUP
HAMILTON GROUP
GENESEE RIVER
IRONDEQUOIT BAY
BIG SODUS BAY
PORT BAY
LITTLE SODUS BAY
OSWEGO RIVER
OSWEGO FALLS
Oswego
188
Rochester
243
Old Lake Ridge
200 ft above Lake Ontario
Sodus
Wolcott
Rose
Hannibal
Gilbertsville Signal
Victory Signal
ONEIDA LAKE
MUD CREEK
Lyons
Clyde
CLYDE RIVER
Clyde Signal
Crusoe L.
Duck L.
Former Terminus of Cayuga Lake
Mosquito Point Bar of Boulder Clay
SENECA RIVER
CROSS LAKE
State Ditch
Montezuma
ONONDAGA L.
Syracuse
150
Signal
253
Signal
891
Auburn
470
Geneva
207
CANANDAIGUA LAKE
423
SENECA LAKE
CAYUGA LAKE
131
OWASCO LAKE
505
SKANEATELES LAKE
634

ANNALS

OF THE

NEW YORK ACADEMY OF SCIENCES.

VOLUME II, 1880—82.

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XVIII.—*Fusion-Structures in Meteorites.*

BY F. G. WIECHMANN.

Read April 10th, 1882.

Meteorites present a theme of study that, from the very nature of the subject, is one of great interest. Interpreted by the spectroscope, it is true, rays of light have borne us knowledge from regions of the heavens so remote, that the mind fails to grasp the actual idea of distance which the figures seek to convey; meteorites, however, these silent messengers from space, present the only tangible source whence information respecting those distant parts may be gleaned.

The thought that by questions correctly addressed,—questions assuming the form of chemical tests and of microscopic examination,—they can be forced to reveal the secrets of their birthplace, lends to their study a certain charm, which all who have devoted themselves to this subject, must have experienced.

It is therefore not surprising that these bodies should frequently have formed the object of study and research, in the laboratory of the chemist as well as in the hands of the microscopist. That particular branch of the microscopic examination of meteorites, however, to which I have mainly confined my attention, has hitherto received but little notice—thus affording ample opportunity for investigation.

Before, however, proceeding to detail the methods and results of observation, it seems desirable to pass in brief review the various theories propounded to account for the existence of meteorites, and to glance at the classifications proposed.

To avoid any possible confusion, I would state that in these pages the term "aërolite" is to be considered as embracing *all*

bodies of ex-terrestrial origin that reach our globe, including thus meteorites, meteoric iron, and meteoric or cosmical dust. The term "meteorite" is to designate all of such ex-terrestrial bodies as are composed of stony and metallic matter, without regard to the proportions in which these two may respectively occur. "Meteoric iron" is to be limited to that class of aërolites formed wholly of metal; while "meteoric dust" is to be confined to that portion reaching the globe in a finely divided state.

The theories that have been advanced to account for the origin of aërolites are quite numerous. They may, however, all be conveniently classed with one or the other of two great divisions, of which the first would claim for them terrestrial sources; the second, cosmical sources.

The first may again be divided into—

(*a.*) Volcanic.
(*b.*) Atmospheric.

The latter into—

(*a.*) Lunar Volcanic.
(*b.*) Planetary.
(*c.*) Solar.
(*d.*) Cometary.

To discuss these theories in detail, is not within the province of this article; after a careful consideration of the merits of each, however, my inclination is to accept the so-called planetary theory advanced by Chladni, and which holds that "meteorites are true though minute planetary fragments, created by the impact and disruption of larger cosmical masses."

Of the many classifications suggested, only Daubreé's will be cited. He divides aërolites into—

SIDERITES.	ASIDERITES.
Containing metallic iron.	Containing no metallic iron.
(1.) *Holosiderous.* Iron or alloys of iron and other metals only.	(1.) *Asiderous.*

(2.) *Syssiderous.*
Iron as a continuous, homogenous mass; also stony and earthy matter.

(3.) *Sporasiderous.*
Iron disseminated in grains. Stony and earthy matter predominates.
(*a.*) Polysiderous. Considerable iron.
(*b.*) Oligosiderous. Little iron.
(*c.*) Cryptosiderous. Iron hardly perceptible.

In studying meteorites with the microscope, it is a frequent occurrence to find in the sections, formations of a very remarkable nature.

These structures exhibiting certain mineral properties, are *not* crystal-forms, as they lack in most instances totally the straight lines and the angles indicative of pronounced crystalline formation; but generally show outlines rounded and curved, in many instances presenting, at first sight, a certain similarity to some well-known types of organic life.

The study of these peculiar structures has for some time past claimed my interest and attention, and this paper is to be the record of the work.

To decide what appellation should be given to these forms, was a matter of considerable difficulty. They are not crystals, yet neither may they be termed amorphous, as they present certain positive recurring shapes. To class them as crystallites might be permissible, for Zirkel's definition, "Crystallites may be termed all those lifeless formations to which a regular radiate structure (*gliederung*) or grouping is peculiar, without their partaking, either as a whole or in their separate parts, of the general properties of crystallized bodies, in particular of a regular polyedral outline,"* is very sweeping and extensive, yet in

* Ferdinand Zirkel: Die Krystalliten: Bonn, 1875, page 5.

the one instance where Zirkel in his work (Plate XVI, Fig. 1) pictures a form approaching to some extent those here under consideration, he designates it as "Krystalliten-aggregation," *i. e.*, aggregation of crystallites.

After mature deliberation, I decided to name these formations "Fusion-structures;" and I trust that the observations detailed further on will justify my choice of an appellation.

After these introductory remarks, it will be in place to present a brief and general outline of the work done, the material used, and the methods employed, and then to take up more in detail such points as may prove of special interest, finally giving the results and conclusions attained.

The investigation embraced the examination of meteorites, lava, rhyolite, tufaceous trachyte and basalt. For the material of which my meteorite-sections were prepared, I am indebted to Drs. C. F. Chandler, J. S. Newberry, T. Egleston, Jr., and C. U. Shepard; and my acknowledgments are also due Mr. Hague, of the U. S. Geological Survey, for the kindness with which he placed a valuable collection of rock-sections at my disposal.

The method of work followed, was to examine each section carefully, with a comparatively low power, 75 diameters, to note any fusion-structure observed, and to study this attentively with higher powers, ranging from 150 to 800 diameters—in one instance even as high as 1,500 diameters; 300 diameters, however, was the one usually employed. Then was noted the behavior of the structure with regard to polarized light, and after this, generally, a rough sketch was made of the structure, and with slide-number attached, placed in a book kept for the purpose. From this book were afterwards chosen the most desirable forms; the respective slides placed under the microscope, and the figures on the plates were then drawn free-hand directly from the glass.

The meteorite sections, of which there were 31 in all, represent seventeen different specimens—care being taken to obtain, wherever possible, both longitudinal and transverse cuts.

Following is a list of these meteorites, recording where known, the place and date of their fall, and in some cases giving their composition, with name of the analyst.

1.	Fell at	Newton County, Arkansas, - - -	———
2.	"	Weston, Connecticut, - - -	December, 1807.
3.	"	Harrison County, Indiana, - - -	———
4.	"	Lenn County, Iowa, - - - -	February 25, 1847.
5.	"	Charles County, Maryland, - - -	February 15, 1825.
6.	"	New Concord, Ohio, - - -	May 1, 1860.
7.	"	Bishopville, South Carolina, - -	March, 1843.
8.	"	Aigle, France, - - - - -	April 26, 1803.
9.	"	Château Renard, France, - - -	June 12, 1841.
10.	"	Staunern, Moravia, - - - -	May 22, 1808.
11.	"	Russel Gulch, Colorado,* - - -	———
12.	"	Esterville, Emmet Co., Iowa, - -	May 10, 1879.
13.	"	Waconda, Mitchell Co., Kansas, - -	———
14.	"	Cabarras County, North Carolina, -	October 31, 1849.
15.	"	Iowa County, Iowa, - - - -	February 12, 1875.
16.	"	Mezo-Maderas, Siebenbürgen, - -	September 4, 1852.
17.	"	Meyellones, Desert of Atacama, - - Bolivia, South America, - - -	———

Concerning the appearance of the fragments obtained, No. 1 is of a black-brown color; No. 7, white, and very brittle to the touch; and the rest nearly all present a dark-gray, stony appearance, with particles of metal disseminated through the mass. Nos. 8 and 10 are in part covered with a black rind of fused material, while No. 14 is noticeable for the brilliancy of the metal specks scattered through its stony portion.

Of the meteorite which fell at Bishopville, S. C. (No. 7 of the list), and which consists essentially of a white mineral, Waltershausen gives this analysis:

Silica, - - -	67.14
Alumina, - -	1.48
Ferric Oxide, - -	1.70
Magnesia, - -	27.11
Lime, - - -	1.82
Water, - -	0.67

Meteorite No. 9, that of Château Renard, France, has, according to Dufrénoy, a Sp. Gr. of 3.56, and consists of—

Olivine, 50 pr. ct.; nickel iron, about 10 pr. ct.; while the remainder appears to be mainly augite and labradorite.

* Meteoric Iron.

No. 17, which was found by Indians near Meyellones, in the Desert of Atacama, S. A., and which is in greater part metal, is, according to E. Ludwig :*

Iron, - - - -	91.53
Nickel, - - -	7.14
Cobalt, - - -	0.41
Phosphorus, - -	0.45
Copper, - - -	trace.
	99.53

Rammelsberg, however, states that the cavities contain a brownish-white silicate of calcium and iron, containing phosphoric acid, perhaps olivine.

Omitting from the list Nos. 11 and 17, as not being strictly meteorites in the sense in which the term is here regarded, fifteen different specimens will remain. In eleven of these I met with fusion-structures, and, having made drawings of some of the most striking, will now call attention to some of the figures on Plates XIX and XX.

The drawings being executed in India ink, of course show only in black and white. The white indicates the mineral matter, the black the metallic portions. Frequently, however, the former was not of a pure white, but tinged with a yellow or brown tint, more or less pronounced, which effect naturally is lost in the plates.

On looking over Plates XIX and XX, it will be seen that the structures depicted are essentially of two kinds :—those in which the mineral matter occurs without intervening metallic material, and those in which the former is scattered through the metal.

A closer examination of some of these structures will now be entered into.

A very remarkable formation is that presented in Plate XIX, Fig. 1. It occurs in (Slide 2) Meteorite 2, which fell at Weston, Conn., December, 1807. It consists of twelve or thirteen bars which are grouped in such a manner as to afford an appearance

* Watts' Dict. of Chem., 2d sup , p. 796. Wien. Acad. Ber., LXIII [2]. 323.

that greatly resembles that of a shell-structure, presenting under 300 D. power even a slightly curved face. Figure 2 is the upper left-hand part of the same structure, but magnified 1,500 D. Bringing so high a power to bear on the object, the latter loses the columnar appearance it shows under lower powers, and now looks like a terrestrial trap-formation. Later on reference will again be made to this structure.

Figure 3, occurs in the same section, and shows the fusion-bars grouped, but more parallel to each other and not exhibiting the tendency to converge to a point, as in Fig. 1.

Figures 4, 5 and 6, same plate, represent a different type of fusion-structures. In all these the bars are so small, that needles would, in these cases, be a more appropriate term; yet they very decidedly evince the tendency to converge at an angle.

Figures 4 and 5 are magnified 300 D.; Fig. 6, however, from a different meteorite (14, Slide 23), is magnified only 75 D.

Figures 7, 8 and 9 fully illustrate the type of the mineral substance scattered through the metal; Fig. 7, showing the convergence-tendency before noticed; Fig. 9, a parallel disposition of the bars; while in Fig. 8 these bars have assumed a more curved form.

In Plate XX, Fig. 3 displays the same curved appearance, but only in part—the lower portion of the structure showing the angular convergence of the needles; Fig. 2 is to illustrate the sharp point to which sometimes the bars are drawn; which same feature one of the structures in Fig. 1 exhibits.

Figs. 4, 5 and 6 need not be further discussed. Figures 7, 8 and 9 are treated of in detail further on, being intended to demonstrate the action of fusion which meteorites suffer on their surface in traveling through the air-envelope surrounding the earth.

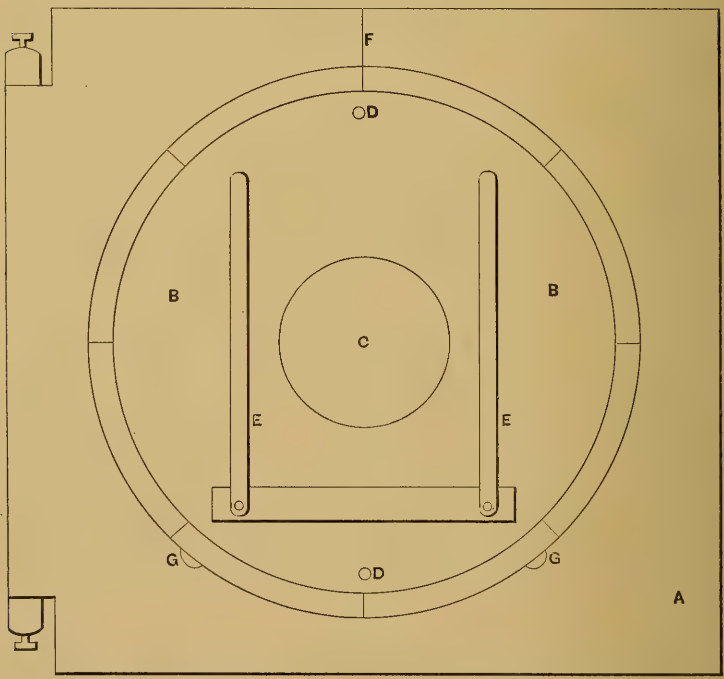
These structures are nearly all magnified 300 D.; some, however, only 75 or 150 D., the exact number is in each instance given in the Plate Index.

All these fusion-structures polarize light; some, however, more than others.

In studying the effect of polarized light on these formations,

I found it indispensable to have some contrivance by which the section under examination might be completely rotated, and yet not be thrown out of the optical axis, the Nicols at the time remaining stationary, crossed so as to give a dark field.

There are various devices to effect this, the most desirable of which is undoubtedly that whereby the whole stage may be rotated; in my instrument, however, the stage is fixed, so I designed a rotation-plate that can be attached or removed as occasion may require, without interfering with the regular stage. As the arrangement is very simple and inexpensive, and may perhaps be found serviceable to others, a brief description may here find place.



A is the fixed stage, 27 mm. long, 21 mm. broad. [This proportion has been slightly altered, to adjust the cut to the page.]

B is the rotation-plate, 17.5 mm. diameter. The centre of this plate has been cut out, forming a circular hole, C, 5.5 mm.

diameter. To the lower part of this, a metal ring has been fastened, which exactly fits into a hole drilled in the fixed stage A, so as to permit the plate B to be completely turned, rotated, resting on A.

D, D, are the knobs attached, while E, E, are the steel springs that hold the slide under examination in place.

B is graduated to any desired scale; in this case, it is graded in 45°.

F is a line engraved on Plate A.

To examine a section by polarized light (crossed Nicols), the slide is fastened by the springs E, E; the line at D is now brought exactly opposite to F, and the Nicols set so as to give a dark field. The plate B is now turned, and whenever a change is shown by the section, a glance at the stage will show through how many degrees it has been turned.

As C is bored in such a manner that its centre is in the optical axis of the microscope, any object placed exactly in this centre can of course be revolved completely without being thrown out of its position in the field.

If, now, it be desired to make use of the fixed stage, the whole of B can simply be lifted out of its place, set aside, two steel clamps intended for this purpose fastened into G, G, and the regular stage is ready for use.

A short time ago, a statement was made that organic forms, recognized as corals, crinoids and sponges, had been discovered in meteorites.

Some few savants—among them, it is said, the illustrious Charles Darwin—accepted the evidence proffered in support of this announcement as conclusive; by far the greater part of scientists, however, brought the full weight of their authority to bear against the assertion, in many instances choosing satire and ridicule as their only mode of attack.

As the photographs produced of the so-called "organic" structures, and a personal inspection of sections of the identical meteorite (*Knyahinya*) from which most of these were taken, convinced me that the structures in question were analogous, if not identical, with those which I was studying, I felt warranted in giving this view of the question a thorough and impartial consideration, before myself advancing a theory of their formation.

Accordingly, I entered upon the investigation entirely unprejudiced, placing before me the question, "Can these structures be of organic origin?"

The first point to be inquired into in this connection will be, whether the various changes and influences to which meteorites are exposed in their course, would permit of the retention of *any definite* structure they may have possessed at the outset, or whether the possibility of this preservation would thereby be precluded.

The specific gravity of meteorites ranges from about 1.7 to 4.0,—Culvier Gravier, in his work, "Sur les Etoiles filantes," giving their mean density as 3.0,—water being chosen as unit.

5.2 is the specifie gravity of Mars; 1.4 that of Jupiter; while 3.0 represents the density of the bodies which circulate in planetary space between these two. Assuming, then, that two of these cosmical masses come into collision,—and the possibility of such an event has been established by careful calculation,—then, owing to the violence of the impact, the masses would burst asunder and the fragments be hurled far out into space. Coming, then, within the limits of attraction of other worlds, gravitation would exert its influence, and, in consequence, these fragments would fall upon their surface—aërolites.

Motion arrested is converted into heat; and it is easy to conceive that, by the force of the collision, heat must be developed; heat so great that it may even cause a partial fusion of the colliding masses. Those aërolites that reach the earth must, moreover, in traveling through the atmosphere surrounding our globe, encounter great resistance from this medium, and the friction thus caused, likewise results in heat-production.

The light-phenomena attending the fall of an aërolite, are doubtless owing to this cause—the heating of the mass being so considerable as to allow the same to attain a luminous state.

Very interesting calculations have been made as to how high a temperature would be thus reached.

The temperature ultimately acquired by the moving body, is the equivalent of the force with which the particles of air come in contact with it. This temperature is stated to be 1° C for a velocity of one hundred and forty-five feet per second, and to go

on increasing with the square of the velocity. The average velocity of a number of well-observed aërolites* may be taken at 34—39 miles per second, and so, it will be readily seen, a very high temperature would be attained.

The heat thus generated is of course sufficiently intense to fuse any substance known ; but it must be remembered that this heat is gradually acquired, and acquired from without to within; and moreover, the body is not exposed for any great length of time to this high temperature ; hence it will naturally follow, that if this temporary heating is to exert any permanent effect, it will be the exterior of the body that will suffer the change.

And so it proves to be. Examination of a number of aërolites reveals the fact that they are covered with a black crust or rind, which crust is the result of fusion. This crust, however, is generally very thin.

To examine into this, I had prepared three sections of the meteorite which fell at Aigle, France, April 26th, 1803 (Meteorite 8, Slides 13, 14, 15). This specimen was of a dark grey color, with one face or side covered with the black fusion-crust.

The first section was cut from the crust only ; the second was prepared from the inner, unaltered portion; while the third was cut from across both crust and unchanged part.

The appearance that these three sections present under the microscope is shown on Plate XX, Figs. 7, 8, 9. Examined with 300 D. power, the first (Slide No. 13) exhibits a highly crystalline structure. The crystals are apparently thrown "criss-cross," the one over the other; generally they are grouped so as to leave in their midst a circular opening which has once been filled by metal,—*i. e.*, they have probably crystallized around some small globule of metal as a nucleus. In most cases, this has been lost in the cutting of the section; in a few instances, however, it remains. This section polarizes beautifully.

The second slide (No. 14) shows a sort of fibrous structure, entirely different from the preceding, as will be seen from Plate

---

* Phipson : Meteors, Aërolites and Falling Stars.

XX, Fig. 8; while the third section exhibits a different picture. The one part, consisting of the fused crust, presents the strikingly crystalline appearance of the first section (No. 13); this portion polarizes nicely. Then follows a dark, black margin, and then comes the gradual transition to the grey, stony part, which is of a decidedly different nature.

It hence appears that the great rise of temperature to which a meteorite is exposed in its travels through the earth's atmosphere,—a temperature sufficiently high to produce the phenomena of light, frequently very brilliant, accompanying its fall,—exerts its influence only over a comparatively small portion of the body, and hence would not effect any material modification or change in the original structure of the meteorite.

The chemical composition of meteorites has frequently been investigated, and numerous analyses of such meteorites are recorded. Moreover, it is no easy matter to take one or two of these analyses and present them as "typical," for as already remarked, they range through all proportions of composition of mineral and metal.

Some few analyses have already been given; here will only be cited the analysis of the meteorite which fell at Orgueil, France, May 14, 1864.

The examination was made by Messrs. Pisani and Cloez, and first published in the Comptes Rendues of 1864; but the figures here given are from a corrected paper sent by M. Pisani to Mr. Phipson,* as the notice first issued contained several misprints.

Cloez.		Pisani.	
Hygroscopic Water, - -	5.957		
Ammonia, - - - -	0.098	Substance dried at 110° C.	
Humus, - - - -	6.027		
Combined Water, - - -	7.345		
Sulphur, - - - -	4.369	Sulphur, - - - -	5.75
Chlorine, - - - -	0.073	Chlorine, - - - -	0.08
Phosphorus, - - -	traces.	Hyposulphurous Acid, -	0.53
Sulphuric Acid, - - -	2.195	Sulphuric Acid, - - -	1.54
Silica, - - - -	24.475	Silica, - - - -	26.08

* Meteors, Aërolites and Falling Stars; 1867, page 116.

Alumina,	1.175	Alumina,	0.90
Oxide of Chrome,	0.225	Chrome Iron,	0.49
Peroxide of Iron,	13.324	Peroxide of Iron,	8.30
Protoxide of Iron,	17.924	Protoxide of Iron,	21.60
Oxide of Nickel,	2.450	Oxides of Nickel and Cobalt,	2.26
Oxide of Cobalt,	0.085	Oxide of Manganese,	0.36
Oxide of Manganese,	1.815	Magnesia,	17.00
Magnesia,	8.163	Lime,	1.85
Lime,	2.183	Soda,	2.26
Soda,	1.244	Potassa,	0.19
Potassa,	0.307		89.19
	99.434		

Cloez groups his results thus:—		Pisani calculates his as follows:—	
Magnetic Oxide of Iron,	20.627	Magnetic Oxide of Iron,	12.03
Magnetic Sulphide of Iron,	7.974	Nickeliferous sulphide of iron,	16.97
Sulphide of Nickel,	3.169	Chrome Iron,	0.49
Silicates,	45.127	Silicates,	55.60
Humus,	6.410	Water and Organic Matter,	14.91
Combined Water,	7.812		
	91.119		100.00

The analysis is very complete, and will again be referred to.

Among the numerous elements determined in meteorites, is carbon. The existence of this substance in meteorites has been thoroughly established by different analysts, and though it is by no means a constituent of the greater number of these bodies, yet its occurrence is of sufficient frequency to have given rise to the class of "carbonaceous meteorites."

The presence of carbon in these meteorites is now to claim attention, bringing into consideration the second item, pertinent to the query under discussion, namely: are there any data which would justify the inference that the agency of life was ever active on those worlds, of which meteorites are the fragments?

The first meteorite in which carbon was discovered, seems to be the one which fell at Alais, Departement du Gard, France, on the 15th of March, 1806.

Thénard made the analysis,* and obtained—

Silica, - - - - -	21.0
Manganese, - - - -	9.0
Oxide of Iron, - - -	40.0
Nickel, - - - - -	2.5
Magnesia, - - - -	2.0
Chrome, - - - - -	1.0
Sulphur, - - - -	3.5
Carbon, - - - - -	2.5
	81.5

In 1834, Berzelius estimated the quantity of carbon to be 3.05 pr. ct.; and Roscoe, in 1862, made a careful examination of the same meteorite. He determined the carbon present to be 3.36 pr. ct. 1.94 pr. ct. of the stone was soluble in ether, from which, on evaporation, crystals were deposited that possessed an aromatic odor, and were fusible at 114° C. On applying heat, they sublimed, leaving a slight carbonaceous residue. Prof. J. Lawrence Smith† has also examined some of the same material, and states the results of his investigation to be in perfect accordance with those of Prof. Roscoe.

In the meteorite which fell at Kold-Bokkeveld, Africa, October 13, 1838, Harris found 1.67 pr. ct. of carbon, and about 0.25 pr. ct. of an organic substance soluble in alcohol; which compound is said to have been of a yellowish color, and of a soft, resinous aspect.

The Kaba meteorite (Hungary), April, 1857, has been analyzed by Wöhler,‡ and found to contain 0.58 pr. ct. of carbon, and besides this a hydro-carbon, resembling wax in appearance, and soluble in alcohol, being extracted by this reagent.

Carbon has been determined in several other meteorites:§ in the one that fell in Sevier County, Tennessee, 1840, by J. Lawrence

* Phipson, p. 114. Annales de Chimie, LXI, 103.

† Researches on the Solid Compounds in Meteorites, 1876.

‡ Phipson, p. 107. Imp. Acad. Sci, Vienna, 1859.

§ Popular Science Review, 1877.

Smith; Cranbourne, Australia, 1861, by Berthelot; Goalpara, India, about 1857, examined by Tschermak, who found in it 0.85 pr. ct. of a hydro-carbon (0.72 carbon and 0.13 hydrogen); Hessle, near Upsala, January 1, 1869, examined by Nordenskjold; this specimen, dried at 110° C, showed 51.6 pr. ct. carbon.

Without entering into details about any of these, I would like to refer once more to the Orgueil meteorite, the analysis of which has previously been given in full.

Cloez determined in it 6.027 pr. ct. of "humus," and this carbonaceous matter, after drying at 110° C., was found to consist of:*

Carbon, - - - -	63.45
Hydrogen, - - -	5.98
Oxygen, - - - -	30.57
	100.00

rather closely resembling the average composition of peat, which may be given as—

Carbon, - - - -	60.06
Hydrogen, - - -	6.21
Oxygen, - - - -	33.73
	100.00

The presence of carbon in meteorites being thus a well-established fact, the question as to its source naturally next presents itself.

According to able researches, the carbon in meteorites occurs in two forms,—as graphite, and as small particles, impalpable in nature, scattered through the mineral portion of the mass.

On the earth, this element occurs in three modifications, as diamond, as graphite, and as coal. Whatever may be the origin claimed for the diamond, as far as graphite and coal are concerned, I am aware of no instance where the parentage of either of these cannot be traced to the action of organic life.

* Phipson: Mëteors, Aerolites and Falling Stars, 1867.

Coal, indeed, is universally admitted to be of organic origin; as to graphite, however, different views seem to be entertained. Yet it appears to admit of but little doubt that graphite is only a modification of the same substance. At Port Henry and at Ticonderoga, New York, graphite occurs in crystalline limestone; and if the graphite anthracite of Newport, R. I., be examined, there will be seen with the graphitic anthracite, coal-plants, distorted and forced somewhat out of form by the force with which the action of metamorphism took place.

A careful examination of different carbonaceous deposits, will in fact reveal the gradual transition of peat to graphite, through all the varying phases of development. There is no abrupt change, no break or chasm, with coal on one side and graphite on the other; but step by step the gradation can be traced, leading from the peat formation to the complete modification as graphite.

Our present knowledge of the subject, however, does not warrant the removal of the question from the field of hypothesis and conjecture, as there may be influences at work of which we are ignorant; yet it certainly seems that the occurrence of carbon in meteorites, as graphite, in an amorphous condition, as hydro-carbon, presents a forcible argument as to life having once played a part in the history of these world-fragments.

And now, these preliminary inquiries disposed of, and it being found that there is nothing in the existing conditions which would preclude the *possibility* of organic structures occurring in meteorites, attention may be directed to the original problem presented, namely:—Are these fusion-structures of organic origin?

The first step taken toward this end, was the study of sections of typical corals, crinoids and sponges. When a knowledge of these forms had been gained, I turned to the examination of the meteoric sections, carefully searching for any structures that would bear out the features of these organized bodies. What forms I found, what outlines they presented, etc., have already been detailed and need not here be repeated; consideration will now be given to the merits of the different arguments presented in support of the claim that these structures are of organic origin.

The method of demonstration resorted to for this purpose is of a two-fold character.* The first may be styled the "negative," inasmuch as it is intended thereby to show that these structures are *not* mineral formations; the second is to be considered as "positive."

As far as the latter line of argument is concerned, the only evidence offered is a considerable number of photographs of the objects in question, accompanied by a history of what *the author considers them*, and an enumeration of the various organic forms (corals, crinoids, sponges) which *he* recognizes therein.

These photographs are for the most part well executed, and bear testimony to considerable labor that must have been expended in their production. However, as to their value as evidence, individual opinion must be formed by personal inspection; for my part, the mere resemblance of outline (which some certainly possess) to the contours of organic structures, does not suffice to convince me of their being such structures—the characteristic details of these, even, being wanting.

Of greater interest are the arguments advanced to show that these structures cannot be mineral forms, and some of these points will now be briefly considered.

"Minerals," it is urged,† "are either crystallized or not crystallized. In the first condition they have definite structure formed in obedience to a law, and hence recurring; they come of planes which in section are projected as straight lines. These forms (lines and angles) are repeated, varying only in size and not in condition (*Verhältniss*." Such forms, it is claimed, are not to be found among these structures, declared to be organic. "Among them," it is said, "is no form with plane or angle; all are spheres (*Kugeln*), ellipses with deviations from the mathematical form, but deviations which are constant. Hence, entirely apart from the coinciding of structure, a constancy of outline is shown, but of other forms than the crystalline forms of olivine or enstatite would have to show."

The claim that no planes or angles are to be found in these structures, is decidedly incorrect, and the very photographs

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* Dr. O. Hahn: Die Meteorite (Chondrite) und ihre Organismen.

† Dr. O. Hahn, *op. cit.*, p. 21.

offered show the fallacy of this statement—to elucidate which still more, a glance at my drawings will suffice.

Figures 1 and 2, Plate XIX, represent a structure I found in a section of the meteorite that fell at Weston, Conn., December, 1807. Fig. 1 is magnified 300 D. Fig. 2 is the left upper portion of Fig. 1, magnified 1500 D. The drawing will serve to indicate the appearance presented; the impression produced under the latter power was like that of seeing a terrestrial trap-formation, entirely doing away with any consideration that might have been entertained of its possible organic origin,—the dots and points that might possibly, under a lower power, have been construed to be channels and tubular openings, resolving themselves into lines of fracture, the columns assuming a prism-like shape.

Figs. 4, 5 and 6, same Plate, will show what a perfect system of angular radiation from different centre-lines, some of these structures possess.

As to the statement*: "Rarely, indeed, small places occur with true crystals, but in a manner which does not in the slightest (*durchaus nicht*) affect the value of proof of these facts," I must observe that it has been my experience to meet with these places quite frequently, and that moreover, in my judgment, they form a very valuable clue indicative of the method of formation of these structures.

The most curious argument (?), however, advanced to support the assertion that these structures are of organic origin, is the following:†

"Finally, attention must be called to a contradiction in which science becomes involved, if the structure of chondrites is to be explained by the mineral property. This is the optical behavior of these inclosures.

"If they were crystals, and if the lamellar fracture (*blätterbruch*) [olivine has none, and yet structures are found in the so-called olivine spheres, hence lamellar fracture!] were the cause of the structure, the mineral would of necessity *have to refract light*. With most of these inclosures, however, no light-refrac-

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* Dr. O. Hahn, *op. cit.*, p. 21.

† *Ibid.*, p. 23.

tion is shown, not even "aggregat-polarization!" Hence they can be neither simple minerals nor crystals, least of all could the structure be explained by lamellar fracture. This fact,—the optical behavior,—should alone have led to the correct interpretation."

This statement is truly remarkable, and if this argument be intended to serve as keystone to the whole structure of theory and observation (?), this structure must fall, for the keystone is worthless.

In the first place, the structures that I found in meteorites *do* polarize light; and, secondly, *true fossil structures of organic origin*, crinoids, sponges and nummulites, which I tested, *also* polarize light; so, even if the statement that these inclosures do not polarize light, should be granted to be true, even then I fail to see how an organic origin can be claimed for them on the strength of this, when *true organized structures* of the kind under consideration *possess the property of polarizing!*

And so, being convinced that the existence of these fusion-structures could not be ascribed to the agency of life, I continued my work in the hope of discovering some clue or data that would serve to unravel the mystery of their formation.

The next step taken was the examination of terrestrial igneous rocks, some of which show a similarity of composition with meteorites.

Besides rhyolite and basalt, there were examined—

A. Scoria from Sandwich Islands.
B. Scoria from Las Valles, New Mexico.
C. Tufaceous trachyte, Lighthouse Rock, Colorado River.
D. Lava from Mount Vesuvius, Italy.
E. Lava from Vesuvius. (Different external appearance.)
F. Lava from Mount Vesuvius. (Different specimens.)

From these six latter specimens, I had in all, thirteen sections made, obtaining in each case longitudinal and transverse cuts.

In A, C, E and F, fusion-structures were found; D did not show them, while B exhibited, very perfectly, the true microlithic structure.

On Plate XXI will be found several of the most characteristic fusion-structures observed in some of these.

Fig. 1 is taken from (Slide A, 1: Longt.) a section of scoria from the Sandwich Islands. The structure polarizes, but not strongly. A glance at the drawing will show the similarity with the forms found in meteorites. This, as all figures on Plate XXI, is magnified 300 D.

Fig. 2 is taken from a section of basalt (U. S. Geol. Expl., 40th Parallel; north of American Flat Creek, Washoe). Polarizes very finely.

Fig. 3 is from a section of rhyolite. (U. S. Geol. Expl., 40th Parallel; N. E. slopes River Range, Nev.) This section appears grey by ordinary light, with a faint tinge of yellow. Only very small parts of the section polarize at all. The structures appear very much like long and curved tubes filled with minute grey dots. The sack-like form in the left part of the field is filled with darker-appearing particles.

Fig. 4 is from a section of lava from Mt. Vesuvius, Italy (E. Slide 10: Transverse). Polarizes very finely. This figure is part of a large structure hexagonal in shape.

Fig. 5 is from tufaceous trachyte of Lighthouse Rock, Colorado River (C. Slide 6: Longt.). This structure also polarizes finely.

And now, having finished the experimental part of the investigation, and having recorded the results obtained and the observations made, it must be considered, to what inferences these will lead, to what conclusions they will entitle us.

The problem to be solved is, then, to word it once more: What are these peculiar formations occurring in meteorites, and to what force or forces do they owe their existence?

The answer to this is to be sought and found in the observations noted on preceding pages; a brief *resumé*, however, will place the matter in a clearer light.

In the first place, the existence of these peculiar formations has been established in a considerable number of different meteorites, which fell at different times and on different parts of the globe. A careful examination has shown that, in every case, these formations exhibit certain constant, recurring forms of outline and structure, that stamp them as a distinct class of mineral bodies.

Secondly, it has been determined that similar structures occur in terrestrial igneous formations, different in kind and coming from different localities, yet each bearing this same mark.

The chemical composition of certain eruptive rocks, is often very similar to that of meteorites; in fact, so closely do the figures of analysis of certain lavas agree with those of some meteorites, that this analogy of composition has been regarded as one of the mainstays of the nevertheless untenable theory, that would assign to meteorites a terrestrial volcanic source.

The origin and method of formation of igneous rocks have been thoroughly investigated and studied; it is well known that these rocks have once all been in the state of fusion, and that then, cooling, slowly or rapidly, according to existing conditions, they finally attained the solid state.

I have not been able to give more than a cursory glance at Vogelsang and Zirkel's valuable work, "Die Krystalliten," yet I believe myself to be only bearing out the observations there noted, in stating, that on the cooling of mineral masses from a state of fusion, frequently there separate—or perhaps segregate—from the main mass, minute granules, globular in form, which granules will be found scattered through the mass.

I am not aware whether any explanation of this phenomenon has been offered and accepted; but to me it seems most likely, that as the mass is not homogenous in composition, certain parts of it, yielding up their heat more readily than the surrounding portions, would naturally contract slightly, and thus form minute particles or globules by themselves in the mass. In support of this suggestion, I may state that, in nearly all, if not in all, cases which I studied, the material forming the structure appeared to be of a different nature from the matter immediately surrounding it.

If a section be taken through a spheroidal body, the resulting cut will be either a circle or of a shape more or less elliptical, according to how the section was made.

The structures encountered, as has been shown, all present rounded or curved outlines; in some cases even approaching very closely to a circle.

Resting, then, on all these facts revealed by observation, I feel justified in declaring, that *these structures represent sec-*

tions cut through such globules formed on the cooling of the mass from fusion, a fact on which rests the appellation, Fusion-structures, which I assigned to them.

Finding these fusion-structures alike in terrestrial igneous formations and in meteorites, we are led to consider another very interesting circumstance.

Terrestrial rocks, whose method of formation is well known, differing from one another in several features, yet all owing their birth to the *same physical forces*, exhibit certain remarkable and distinctive structures in their formation.

Extra-terrestrial bodies, meteorites, in many cases analogous in composition to the former, show with great frequency these *identical, distinctive structures.*

The conclusions to which these facts lead are obvious. There is no accident in nature: like causes, under like conditions, produce like effects.

The structures in the rocks examined, were found to be sections through globules, which globules were produced on cooling after fusion; the structures in the meteorites are identical with the structures in the igneous rocks; therefore, they too must be the result of the cooling after a state of fusion.

That these globules in meteorites could not have been formed during the partial fusion that such bodies experience in passing through the envelope of air surrounding the earth, has been proven by the facts previously stated (pages 299 and 300); therefore, plainly and unmistakably, these structures, these records in stone, bear evidence that fusion and subsequent cooling must have formed a chapter in the history of those worlds of which these meteorites are but the scattered fragments.

NOTE.

The drawings on the three accompanying Plates were executed free-hand, in preference to making use of a camera lucida.

Had photography been resorted to, the forms depicted would undoubtedly have been obtained with greater accuracy in outline and detail than it is possible to procure, even in the most conscientious free-hand work. The latter, however, offers the inestimable advantage of permitting the structure studied, and this structure *only*, to be shown; while photography necessarily introduces all that lies above and beneath, and in the immediate neighborhood of the object under the glass of the microscope.

Hence, whenever on the Plates an object is drawn in the centre of the field, the rest of the space being left blank, it must be understood that the surrounding matter has been simply ignored in the drawing, as being foreign to the structure studied.

INDEX TO PLATES.

PLATE XIX.

Figure.	No. of Meteorite.	No. of Slide.	Diameters Magnified.
1	2	2	300
2	2 (Left upper part of 1.)	2	1500
3	2	2	300
4	2	30	300
5	2	30	300
6	14	23	75
7	14	23	300
8	14	23	300
9	5	8	300

PLATE XX.

Figure.	No. of Meteorite.	No. of Slide.	Diameters Magnified.
1	6	11	300
2	10	17	300
3	16	27	150
4	2	2	150
5	9	16	600
6	15	25	300
7	8	(Exterior.) 13	300
8	8	(Interior.) 14	300
9	8	(Both.) 15	300

The meteorite numbers refer to page 293.

PLATE XXI.

Figure.	Material.	Locality.	Diam. Mag.
1	Scoria	Sandwich Islands.	300
2	Basalt	North of Am. Flat Creek, Washoe.	300
3	Rhyolite	N. E. slopes River Range, Nev.	300
4	Lava	Mt. Vesuvius, Italy.	300
5	Tufaceous Trachyte	Lighthouse Rock, Colorado R.	300

XIX.—*Index to the Literature of Electrolysis and its Applications,*

1784–1880.

BY W. WALTER WEBB.

Read April 24th, 1882.

The following Index is confined to the literature of electrolysis and its applications, especially in electro-metallurgy; the whole subject of the various forms of the galvanic battery, its theory and uses, has been omitted; electro-capillarity and passivity are, however, included.

It is not claimed that the Index is complete, yet care has been taken to make it include the best-known English, French and German journals.

I must express my thanks to Prof. H. C. Bolton for his suggestion of the idea of compiling such an Index, for his kindness in allowing the plan of those published by himself to be copied, and for much assistance which he has given me.

I am indebted to the Index of the Literature of Ozone, published by Professor Leeds, for many of the references in the following Index.

W. W. W.

TRINITY COLLEGE,
APRIL, 1882.

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[For list of authorities, with abbreviations, etc., see the close of the Index.]

Index to the Literature of Electrolysis.

1784	Cavendish	Phil. Trans., LXXIV, 119.	Effect of the spark on air.
	Kirwan	" LXXIV, 154.	The same.
1785	Cavendish	" LXXV, 372.	The same.
	Van Marum	Quoted by Cahours, C. R., LXX, 369.	Ozone by the spark.
1788	Cavendish	Phil. Trans., LXXVIII, 261.	Nitrous Acid by the spark.
1789	Milner	" LXXIX, 300.	The same.
	Troostwyk	Journ. de Phys., Nov., 1789.	Decomposition of water.
	Van Marum	A. c. p., XI, 270.	Effect of the spark on CO_2.
1790	Keir	Phil. Trans., 1790, 359.	Precipitation of metals.
1797	Henry	" LXXXVII, 401.	Electrolysis of "carbonated hydrogenous gas."
	Pearson	" XC, 188. Gilb. Ann., VI, 370.	Electrolysis of water.
1800	Nicholson	Nich., J., XLII, 183.	Decomposition of water.
1801	Cruikshank	Gilb. Ann., VII, 106.	Electrolysis of H_2SO_4.
	Gautherot	A. c. p., 1, XXXIX, 203.	Decomposition of water.
	Gilbert	" 1, XLI, 107.	The same.
	Ritter	Gottl. Alm., 1801.	Electro-chemical decomposition.
	Simon	Gilb. Ann., VIII, 35.	Decomposition of H_2SO_4.
	Vauquelin	A. c. p., 1, XXXIX, 103.	New experiments in galvanism.
1802	Facquez	" 1, XLIII, 306.	Decomposition of HCl.
	"G. H."	Nich., J., 2, II, 185.	Electrolysis of "carbonated hydrogen."
	Wollaston	A. c. p., 1, XL, 169.	Electro-chemical decomposition.
1803	Davy	" 1, XLIV, 206.	Action of galvanic electricity.
	Gahn	Gilb. Ann., XIV, 235.	Electrolysis of arsenate of potassium.
	Hisinger and Berzelius	Geh., J., I.	Electro-chemical decomposition.
	Simon	A. c. p., 1, XLV, 182, 13.	Decomposition of H_2O.
1804	Wilkinson	Nich., J., 2, IX, 243.	The same.
1805	Brugnatelli	Phil. Mag., 1805.	Gilding.
	Pacchiani	A. c. p., 1, LV, 15; 1, LVI, 152.	Decomposition of HCl.
	Sylvester	Nich., J., 2, X, 106.	Decomposition of H_2O.
1806	Grotthuis	A. c. p., 1, LVIII, 10, 54.	The same.
	Kidel	Nich., J., 2, XIV, 134.	Analysis by electrolysis.
	Pacchiani	A. c. p., 1, LX, 314, 325.	Decomposition of HCl.
	Riffault	" 1, LVI, 182.	The same.

1806	Sylvester	Nich., J., XV, 50, 28.	Experiment in electrolysis
	Wilkinson	" XIV, 342, 28.	Supposed production of HCl from H_2O by electrolysis.
1807	Alemani	A. c. p., 1, LXV, 323; Phil. Mag., 1, XXVIII, 339.	Electrolysis of H_2O and HCl.
	Chompré	A. c. p., 1, LXI, 58.	Electrolysis of HCl and $KClO_3$.
	Berzelius	" 1, LXI, 258.	Electrolysis of HCl.
	Davy	Phil. Trans., XCVII, 1; Phil. Mag., 1, XXVIII, 1, 104, 220; Nich., J., 2, XVIII, 359; 2, XVI, 79.	Decomposition by electricity.
	Guyton	Nich. J., 2, XXIII, 263.	Electrolysis of sulphides.
	Hisinger and Berzelius	Gilb., Ann., XXVII, 301.	Electrolysis of concentrated H_2SO_4.
	Launay	Phil. Mag., 1, XXVII, 260.	HCl by electrolysis.
	Pfaff	A. c. p., 1, LXII, 23.	Electrolysis of HCl.
	Riffault and Chompré	" 1, LXIII, 73.	Theory of electrolysis.
	Sylvester	Gilb., Ann., XXV, 454.	Precipitation of metals.
	Veau de Launay	Nich. J., 2, XVIII, 155, 28.	HCl by electrolysis.
1808	Bucholz	A. c. p., June, 1808, 266; Gehl., J., XVII; Nich. J., 2, XXV, 39.	Electrolysis by weak currents.
	Davy	Phil. Trans., XCVIII, 33; Phil. Mag., 1, XXXII; 1, 101, 146; Nich. J., 2, XIX, 37; XX, 290; A. c. p., 1, LXIII, 172; LXIV, 319; LXVIII, 205, 225.	Na and K by electrolysis.
	Descostils	A. c. p., 1, LXIII, 77.	Electrolysis of salts.
	Seebeck	N. Gehl., V, 482.	NH_4 amalgam by electrolysis.
	Sylvester	Nich., J., 2, XIX, 157.	Electrolysis of the alkalies.
	Théodore	A. c. p., 1, LXIII, 5.	Electrolysis of metals.
1809	"A. B."	Phil. Mag., 1, XXXIII, 87.	On Davy's theory.
	Brande	" 1, XXXV, 111.	Electrolysis of blood.
	Davy	" 1, XXXVI, 17; A. c. p., 1, LXX, 189, 225; Nich. J., 2, XVI, 321.	Electrolysis of N and NH_3.
	Davy	Phil. Trans., 1810, part 1; Phil. Mag., 1, XXXV, 401.	Electrolysis of Na and K.
	Davy	Nich., J., 2, XXII, 149.	Letter on electrolysis.
	Bucholz	Gehl., J., VII, 734.	Precipitation of metals.
	Pfaff	Nich., J., 2, XVII, 362, 28.	HCl by electrolysis.
	Singer	" 2, XXIV, 174, 28.	Electro-chemical experiments.
	Sylvester	" 2, XXIII, 258.	Electrolysis.
	Van Mons	" 2, XXXIV, 179.	The same.
1810	Davy	Phil. Trans., C, 16; A. c. p., 1, LXXV, 27, 129.	Electro-chem. researches.
	Gay-Lussac and Thénard	A. c. p., 1, LXXIII, 197; Phil. Mag., 1, XXXV, 307.	Electrolysis of NH_3.

1810	Wollaston	A. c. p., 1, LXXIV, 299.	Electrol. of the secretions.
1811	Anderson	Nich., J., 2, XXX, 183.	Electrolysis of H_2O.
	Davy	" 2, XXIX, 112.	Electrolysis of O.
	Donovan	Phil. Mag., 1, XXXVII, 227, 245.	Davy's theory.
	Gay-Lussac and Thénard	A. c. p., 1, LXXVIII, 245.	Electrolysis.
	Grotthuss	" 1, LXIII, 5; Nich. J., 2, XXX, 112.	Metallic arborizations.
	Heinskin	Nich. J., 2, XXX, 157, 28.	Electrolysis of Na_2CO_3.
1812	Singer	" 2, XXXI, 90, 216.	Electrolysis.
	Murray	" 2, XXXI, 87.	Electrolysis of H_2O.
1813	Avogadro	A. c. p., 1, LXXXVII, 286.	Berzelius's theory.
	Berzelius	" LXXXVI, 146.	Theory of electrolysis.
1814	Brande	Phil. Mag., 1, XLIV, 124.	Electrolysis.
1815	Donovan	" XLV, 154, 308, 380.	Metallic arborization.
1818	Acton	Phil. Mag., 2, II, 112.	K by electrolysis.
1821	Wollaston	A. c. p., 2, XVI, 45.	Electrolysis.
1822	Fisher	Gilb. Ann., LXXII, 289.	Precipitation of metals.
	Van Mons	" LXXIII, 310.	Arborizations.
	Witting and Bischoff	" LXXIV, 424.	The same.
1824	Becquerel	Mem. de l'Acad., XI, 33.	Electrolysis with weak currents.
1825	De la Rive	A. c. p., 2, XXVIII, 190.	Electrolysis.
	Ferré	" XXVIII, 417; T. Ann., N. S., X, 262.	Application of the theory of electrolysis.
	Fisher	Pogg., IV, 291; VI, 43.	Precipitation of metels.
1826	Davy	Phil. Trans., CXVI, Pt. 3, 383.	Electrolysis and chemical changes.
	Davy	Phil. Trans., 1825, Pt. 2; Phil. Mag., 2, LXVII, 89; T. Ann., N. S., XI, 248.	Preservation of metals by electrolysis.
	Dumas	A. c. p., 2, XXXIII, 265.	Electrolysis of $CaCO_3$.
	Fisher	Pogg., VIII, 488; IX, 255.	Precipitation of metals.
1827	Becquerel	A. c. p., 2, XXXV, 113, 23.	Electrolysis by weak currents.
	Davy	Phil. Mag., 2, I, 31, 94, 190.	History of electrolysis.
	De la Rive	A. c. p., 2 XXXV, 164; Pogg., X, 311.	Electrolysis of bromine.
	Fisher	Pogg., X, 603.	Precipitation of metals.
	Nobili	A. c. p., 2, XXXIV, 280, 419.	New phenomena in electrolysis.
	Pouillet	" XXXVI, 5.	Electrolysis.
	Sérullas	" XXXIV, 192.	The same.
1828	Davy	Phil. Trans., 1826, Pt. 3; Rep. of Arts, 3, V, 76.	Electrical and chemical relations.
	Fisher	Pogg., XII, 499.	Precipitation of metals.
	Libri	Edinb. So. Sci., 1, IX, 353; A. c. p., 2, XXXVIII, 100; Rep. of Arts, 3, VIII, 116.	Electrolysis of odorous substances.
1829	Fisher	Pogg., XVI, 124; Kastn. Archiv., XVI, 219.	Precipitation of metals.

1829	Becquerel	A. c. p., 2, XLI, 5 ; XLII, 225 ; Pogg., XVI, 306 ; Phil. Mag., 2, VII, 61 ; Berzl., J. B., VIII, 20.	Electrolysis by weak currents.
1830	Becquerel	A. c. p., 2, XLIII, 131, 380; Pogg., XVIII, 143; Berzl., Jahresb., X, 29 ; Phil. Mag., 2, VII, 226.	The same.
	Bonijol	Bibl. Univers., Oct., 1830. Am. J. Sci., 1, XX, 179.	Electrolysis of H_2O by atmospheric electricity.
	Dumas	Rep. of Arts, 3, VIII, 370.	Deposits in lead pipe.
1831	Arago	" 3, XII, 119.	Electrolysis of zinc.
	Barry	Phil. Mag,, IX, 357, 33.	Electroly. by atmospheric electricity.
	Becquerel	A. c. p., 2, XLVIII, 337.	Electrolysis of oxides of Fe and Mn.
	Brande	Pogg., XXII, 308 ; Phil. Mag., 2, IX, 237.	Electrolysis of organic substances.
	?	Br. A. A. Sci., 1831–32, 468.	Electro-metallurgy.
1832	Becquerel	Pharm. Centrl., III, 527.	Titanium by electrolysis.
	Bonijol	J. Roy. Inst., I, 293; Am. J. Sci., 1, XXI, 368.	Decomp. of water by atmospheric electricity.
	Botts	Bibl. Univ., Sept., 1832 ; Am. J. Sci., 1, XXIV, 197.	Electrolysis.
	Hachette	A. c. p., 2, Sept., 1832; Am. J. Sci., 1, XXIV, 142.	Electrol. by the electric induction spark.
1833	Becquerel	A. c. p., 2, LII, 240.	Effect of vegetation on electrolysis.
	Becquerel	Mem. de l'Acad., XII, 581 ; A. c. p., 2, LIII, 105 ; Pogg., XXXI, 46 ; Am. J. Sci,, 1, XVII, 383.	Electrolysis by weak currents.
	Bouchardat	Dingl., J., L, 289; J. Pharm., 1833, 457.	Electrolysis.
	Faraday	F. R., I, 87, 127; Phil. Mag., 2, III, 253, 450.	Electrolysis by frictional electricity.
1834	Avogadro	Mem. de l'Acad. Sci. T., II, 1; A. c. p., 2, LXXI, 5.	Electrolysis.
	Bessemer	Mech. Mag., 1864, 73.	Electro-metallurgy.
	Faraday	F. R., I, 195, 259 ; Phil. Mag., 3, IV, 291; V, 161, 252, 334, 424, 456 ; VI, 34, 125, 171, 272, 331, 410.	Electrolysis.
1835	Aimé	C. R., I, 471.	Electro-chem. apparatus.
	Becquerel	A. c. p., 2, LX, 164; Berl., Jahresb., XIV, 791.	Electrolysis by weak currents.
	Becquerel	C. R., I, 455.	Electro-chem. apparatus.
	Begriff	Ann. Ch. Pharm., XVI, 129.	Electrolysis.
	Botts	Bibl. Univ., 1835, 120; Am. J. Sci., 1, XXIX, 369.	Electrolysis by terrestrial magnetism.
	Connell	Edinb. N. Phil. J., XIX, 159.	Electrolysis of ethers.
	Martens	Bull. Acad. Brus., II, 57, 18.	Theory of electrolysis.
	Poggendorf	Phil. Mag., 3, VII, 421.	Vindication of Faraday.
	Van Mons	Bull. Acad. Brus., I, 11, 199.	Theory of electrolysis.

1835	Walford	Phil. Mag., 3, VIII, 170,	Davy's theory of electrolysis.
1836	Becquerel	C. R., II, 230.	Extraction of Ag from the ore.
	De la Rive	Phil. Mag., 3, IX, 234.	Nobili's discoveries.
	De la Rive	" 1836.	Electro-metallurgy.
	Einbrodt	A. c. p., 2, LXI, 262.	Theory of electrolysis.
	Elkington	Rep. of Arts, 4, VIII, 223.	Gilding.
	Faraday	Phil. Mag., 3, IX, 60.	Passive iron.
	Gherardi	Nov. Com. Bon., 1, V, 132.	Heat in electrolysis.
	Paillette	C. R., III, 724.	Electro-chem. phenomena.
	Schönbein	Pogg., XXXVIII, 449.	Passive iron.
	Solly	Phil. Mag., 3, IX, 53 ; 3, VIII, 130.	Electrol. of Cl, Br, I.
	?	Dingl. J., LXII, 77.	Arborization.
1837	Becquerel	C. R., IV, 824.	Electrolysis in soluble bodies.
	"	" 831.	Influence of surface on electrolysis.
	"	" V, 88 ; Berzelius, Jahresb., XVI, 129.	Electrolysis in the formation of minerals.
	"	Phil. Mag,, 3, X, 154.	Extraction of minerals by electrolysis.
	Bird	" " 357 ; J. pr. chem., X, 310.	Electrolysis of albumen.
	Bird	Phil. Mag., 3, X, 376.	Electrolysis by long continued currents.
	Connell	" " 93.	Electrol. of iodic acid.
	Cross	C. R., IV, 882.	Compounds by electrol.
	De la Rive	Ann. Chem. Pharm., XXIV 160.	Electrolysis of chemical compounds.
	Dulk	Ann. Chem. Pharm., XXIV 161.	The same.
	Elkington	Rep. of Arts, 4, VIII, 354.	Platinum electro-metallurgy.
	Faraday	Phil. Mag., 3, X, 175.	Effect of electrolysis on iron.
	Fox	" " 171.	Crystals by electrolysis.
	Noad	" " 276; " XI, 48.	Effect of electrolysis on iron.
	Paillette	C. R., IV, 342.	New substance by electrolysis.
	Pouillet	" 785.	Electrolysis of water.
	Schönbein	Phil. Mag., 3 ,X, 133, 172, 267, 425.	Passive iron.
	Sturgeon	Ann. Elect., I, 11.	Analysis by electrolysis.
1838	Becquerel	C. R., XXII.	Electrolysis by weak currents.
	Bird	Ann. Elect., II, 30; Phil. Mag., XIII, 379, 3 sr.	Platinum electrodes.
	Bird	Am. J. Sci., 1, XXXIII, 267.	Crystals by electrolysis.
	Böttiger	Phil. Mag., 3, XI, 298.	Colors by electrolysis.
	Clarke	Am. J. Sci., 1, XXXIII, 217.	Electrolysis by magneto-electricity.
	Elkington and Barratt	Br. Pat. Rep., 1838, 1742; Lond. J., XIX, 79.	Electro-metal. of zinc.

1838	Faraday	Phil. Mag., 3, XI, 206, 358.	Electrolysis.
	Lepage	C. R., VI, 420.	Passive iron.
	Matteucci	Phil. Mag., 3, XIII, 469.	Platinum electrodes.
	Pasley	Bull. Soc. l' Ind., XXXVII, 123.	Passive iron.
	Schönbein	C. R., VI, 421, 277.	Peroxides by electrolysis.
	Schönbein	Phil. Mag., 3, XI, 311.	Action of peculiar currents
1839	Becquerel	C. R., VIII, 783.	Sulphates by electrolysis.
	Becquerel	" VIII, 497.	Electrolysis of water.
	Böttiger	Ann. Ch. Pharm., XXIX, 77	Electrolysis.
	Daniell	Phil. Mag., 3, XV, 317; Phil. Trans., 1837.	Electrolysis of binary compounds.
	Guggsworth	Ann. Elect., March, 1839.	Electro-metallurgy.
	Grove	C. R., VIII, 802.	Electrolysis of water.
	Jacobi	Phil. Mag., 3, XV, 161.	Mixed O and H by electrolysis.
	J. B.	" 3, XIV, 446.	Platinum electrodes.
	Maas	Bull. Acad. Brus., 1, VI, 2, 438.	Passive iron.
	Matteucci	C. R., VIII, 840; A. c. p., 2, LXXIV, 99.	Electrolysis.
	Van Mons	Bull. Acad. Brus., 1, II, 199.	Electro-chemical theory.
1840	Arago	C. R., X, 375, 870.	Electro-metallurgy.
	Becquerel	Bull. Soc. l'Ind., XXXIX, 407.	Electrolysis of silver.
	Boquillon	C. R., X, 771; XI, 25, 120; Bull. Soc. l'Ind., XXXIX, 305, 339.	Electro-metallurgy.
	Böttiger	Pogg., L, 45.	Electrol. of Mn. salts.
	Boutowski	C. R., X, 841.	Electro- metallurgy.
	Brongniart	" XI, 768.	The same.
	Cartwright	Ann. Elect., V, 236.	Electrotypes.
	Coulier	C. R., XI, 531, 825.	Electro-metallurgy.
	Daniell	Phil. Mag., 3, XVII, 297, 349; Ann. Ch. Pharm., XXXVI, 321; Arch. Elect. I, 594.	Electrolysis of binary compounds.
	De la Rive	Bull. Soc. l'Ind., XXXIX, 190; Arch. Elect., I, 669; A. c. p., 3, LXXIII, 398; C. R., X, 578; XI, 25, 913.	Electro-gilding.
	De la Rive	Pogg., LIV, 402.	Electrodes of Pt., Ag and Cu.
	Demidoff	C. R., X, 375.	Electro-metallurgy.
	Dumas	Ann. Ch. Pharm., XXX, 288; Phil. Mag., 3, XVII, 183.	Theory of electrolysis.
	Elkington	Br. Pat. Rep., 1840, 8447; Rep. of Arts, 4, XVI, 239; Lond. J., XIX, C. S. 83; Mech. Mag., XXXIII, 397; Ann. Electr., VII, 377; C. R., XIII, 636, 998.	Electro-gilding.
	Faraday	F. R., II, 25, 59.	Electrolysis.
	Gorke	Phil. Mag., 3, XVII, 299.	Electro-chem. equivalents.

1840	Jacobi	Anz. Polyt. J., LXXV, 110.	Applications of electrol.
	Jotard	C. R., XI, 713.	Electro-metallurgy.
	Kobell	Bull. Soc. l'Ind., XXXIX, 481; XL, 10.	The same.
	Krasner	C. R., XI, 712.	The same.
	Lockett	Br. Pat. Rep., 1840, 8610; Lond. J., XIX, C. S. 89; Mech. Mag., XXXIV, 221.	The same.
	Perrott	C. R., XI, 1063.	The same.
	Richoux	" XI, 636.	The same.
	Schönbein	Basel. Ber., IV, 66; Bibl. Univ., XXVIII, 342; Pogg., L, 616; Arch. Elect. IV, 333; Phil. Mag., 3, XVII, 293; Proc. R. Soc. IV, 226; Edinb. N. Phil. J., XXIX, 178; C. R., X, 679; Ann. Elect., VII, 470; Am. J. Sci., 1, LXI, 43; Br. As. A. Sci., 1840, 209.	Ozone by electrolysis.
	Shore	Br. Pat. Rep., 1840, 8407; Ann. Elect., VII, 38.	Electro-metallurgy.
	Solly	Phil. Mag., 3, XVI, 309.	Precipitation of Cu. by electrolysis.
	Soyer and Ingé	C. R., XI, 292.	Electro-metallurgy.
	Spencer	Br. Pat. Rep., 1841, 8865; Rep. of Arts, XVI, N. S., 287; Lond. J., XX, C. S., 166; Mech. Mag., XXXV, 282; Inv. Adv., V, 180; G. Sci. Mis., IV, 62; Ann. Elect., VII, 380; Am. J. Sci., 1, XL, 157.	The same.
	Sturgeon	Ann. Elect., V, 484.	Electrotypes.
	Von Kobell	Gel. Anz., LXXXVIII, LXXXIX; J. pr. Chem., XX, Nos. 3, 4; Ann. Elect., V, 198.	The same.
1841	Arago	C. R., XII, 509, 779, 957.	Electro-metallurgy.
	"	" XIII, 26.	Electro-metallurgy in photography.
	Barratt	Br. Pat. Rep., 1841, 9077; Rep. of Arts, XVII, N. S., 367; Mech. Mag., XXXVI, 476; Lond. J., XX, C. S, 438.	Electro-met. of alloys.
	Becquerel	Arch. Elect., 1, 281.	Electrolysis of water.
	"	C. R., XVII, and XVIII; Ann. Elect., VI, 411.	Chemical force of currents
	Boquillon	C. R., XIII, 833, 1157; Ann. de M., III, XIX, 429; Bull. Soc. l'Ind., XL, 10.	Electrotypes.
	Connell	Arch. Elect., I, 401; Phil. Mag., XVII, 353.	Electrolysis of alcohols.
	David	C. R., XIII, 965.	Electro-metallurgy.
	Davy	Ann. Elect., VII, 173.	Electrolysis.

1841	Dent	Am. J. Sci., 1, XLI, 402.	Electro-gilding.
	De la Rive	Arch. Elect., I, 175.	Electrolysis by magneto-electricity.
	Fizeau	C. R., XII, 401.	Electo-metallurgy in photography.
	Grove	Phil. Mag., 3, XIX, 99; XVIII, 543.	Electro-nitrogurets.
	Hunt	Ibid., 3, XIV, 442.	Electrol. of copper salts.
	Jordan	Ann. Elect., VIII, 239; Phil. Mag., 3. XIX, 452.	Electro-metallurgy.
	Joule	Phil. Mag., 3, XIX, 265.	Heat evolved in electrol.
	Leseuer	C. R., XIII, 29.	Electro-metallurgy.
	Mallet	Br. Pat. Rep., 1841, 9018.	Preservation of ship-sheathing.
	Matteucci	Arch. Elect., I, 340.	Electrolysis.
	Melloni	C. R., XII, 219.	Electrotypes.
	Moyle	Ann. Elect., VI, 112.	The same.
	Parks	Br. Pat. Rep., 1841, 8905; Rep. of Arts, 4, XVII, 199.	Electro-metallurgy.
	Ruolz	C. R., XIII, 342.	Electro-gilding.
	Soyer	" 787.	Electro-silvering.
	Soyez	Bull. Soc. l'Ind., XLI, 83.	Electrotypes.
	Sturgeon	Ann. Elect., VI, 79.	The same.
	Talbot	Br. Pat. Rep., 1841, 9167; Rep. of Arts, I, E. S., 47; Lond. J., XXI, C. S., 357; Mech. Mag., XXXVI, 496; Eng. and Arch. J., V, 358.	Electro-metallurgy.
	Traffant	C. R., XIII, 1100.	Electro-gilding.
	Walker	Phil. Mag., 3, XIX, 328; Arch. Elect., II, 466.	Electro-metallurgy.
1842	Becquerel	C. R., XIV, 77, 121; XV, 433; Arch. Elect., II, 465.	Applications of electrol.
	Becquerel	Ann. Elect., IX, 491.	Secondary products by electrolysis.
	Bilfied-Lefévre	C. R., XV, 32.	Electro-metallurgy.
	Boquillon	" XV, 507.	The same.
	Charrière	" XIV, 457.	The same.
	Cornay	" XV, 678, 850.	The same.
	Crosse	Phil. Mag., 3, XXI, 64.	Electrolysis of minerals.
	De la Rive	Arch. Elect., II, 468; Ann. Elect., VIII, 216, 333.	Electrol. of natural waters.
	Elkington	Bull. Soc. l'Ind., XLI; Ann. Elect., VIII, 125; Arch. Elect., II, 111.	Electro-metallurgy.
	Gann	" II, 236.	Ozone by electrolysis.
	Gannal	C. R., XV, 685.	Electro-metallurgy.
	Grove	Arch. Elect., II, 457.	Electro-metallurgy in photography.
	Jacobi	" II, 432.	Electro-metallurgy.
	Lieson	Br. Pat. Rep., 1842, 9374; Lond. J., XXII, C. S., 292; Mech. Mag., XXXVIII, 59; Rec. Pat. Inv., I, 353.	The same.
	Martens	Arch. Elect., II, 558.	Electrolyses.

1842	Matteucci	Ann. Elect., IX, 34.	Electrol. of silver salts.
	Pearson	" IX, 496.	Electrolysis of water.
	Perrot	C. R., XIV, 370.	Electro-metallurgy.
	Peyré	" XIV, 73; Bull. Soc., l'Ind., XLI. 55.	The same.
	Poggendorff	Arch. Elect., III, 117; Ann. Elect., IX, 143.	Ferric acid by electrol.
	Ruolz	C. R., XIV, 252; XV, 280, 466; Bull. Soc. l'Ind., XLI, 424.	Electro-metallurgy of zinc.
	Schönbein	Arch. Elect., II. 241, 509.	Electrolysis.
	Sorel	C. R., XIV, 228, 339.	Electro-metallurgy of zinc.
	Soyer	" XV, 466.	Electro-metallurgy.
	"	" XV, 784.	Bodies preserved by electro-metallurgy.
	Tuck	Br. Pat. Rep., 1842, 9379; Lond. J., XXII, C. S., 458; Rec. Pat. Inv., I, 373.	Electro-metallurgy.
	"V"	Phil. Mag., 3, XX. 72.	New theory of electrolysis.
	Von Kobell	Bull. Ac. Sci. Br., 1, IX, 2°, 315; Am. J. Sci., 1, XLVIII, 222.	Electro-metallurgy.
	Weber	Arch. Elect., II, 661.	Electrolysis of water.
	Wollaston	Ann. Elect., IX. 518.	The same.
1843	Arago	C. R., XVI, 503.	Electro-metallurgy.
	Barratt	Br. Pat. Rep., 1843, 9786; Lond. J., XXIV, C. S., 24.	The same.
	Becquerel	C. R., XVII, 1, 53; A. c. p., 3, VIII, 402; Arch. Elect., III, 345; Ann. Elect., X 151.	Metallic oxides by electrol.
	"	C. R., XVII, 87, 837; Arch. Elect., III, 671.	Electro-metallurgy.
	Blackwell	Br. Pat. Rep., 1843, 9041; Rep. of Arts III, E. S., 363; Lond. J., XXVI, C. S., 16; Mech. Mag., XLII, 108.	Electro-metallurgy of Cu.
	Boquillon	C. R., XVII, 1198, 1263.	Discussion about electrol.
	De la Rive	Arch. Elect., III, 308; C. R., XVI, 1089.	Ozone by electrolysis.
	"	Arch. Elect., II, 175.	Electrolysis of alcohol.
	"	C. R., XVI, 881.	Heat in electrolysis.
	Dujardin	" XVII, 1200.	Electro-metallurgy.
	Hare	Phil. Mag., XXII, 460.	Electrolysis of salts.
	Hull	Br. Pat. Rep., 1843, 9917.	Elec. of fermented liquors.
	Hulot	C. R., XVII, 1309.	Electro-metallurgy.
	Mallet	Arch. Elect., III, 661.	Bodies preserved by electro-metallurgy.
	Mourey	C. R., XVII, 37.	Electro-metallurgy of Ag.
	"	Ann. d. M., 4, III, 579; C. R., XVI, 660.	Silver-plating.
	Paret	C. R., XIV, 1001.	Electrolysis by magneto-electricity.
	Pelouze	" XVI, 766.	Electro-metallurgy in photography.

1843	Poggendorff	Pogg., LXXVI, 586.	Electrol. of bismuth salts.
	Poole	Br. Pat. Rep., 1843, 9741; Rep. of Arts, III, E. S., 6; Lond. J., XXIV, C. S., 14; Mech. Mag., XL, 14.	Electro-metallurgy.
	Schönbein	Pogg., LIX. 240; Arch. Elect. III, 295.	Ozone by electrolysis.
1844	Becquerel	C. R., XVIII, 362; Arch. Elect., IV, 156, 224; Phil. Mag., 3, XXV, 73.	Electrolysis.
	"	A. c. p., 3, XI. 162. 257; Arch. Elect., IV, 557.	Electrolysis by terrestrial currents.
	"	C. R., XVIII, 197.	Metallic oxides by electrol.
	"	" XVIII, 449, 554, 715; Arch. Elect., IV, 520. 552.	Precipitation of metals.
	Bietz	Pogg., LXI, 209; Arch. Elect. IV, 276.	Electrolysis.
	"	Pogg., LXII, 234.	Passive iron.
	Boquillon	C. R., XIX, 440.	Electro-metallurgy.
	Christofle	" XIX, 405; Bull. Soc. l'Ind., XLIII, 193.	The same.
	Connel	Arch. Elect., IV, 265.	Electrolysis of salts.
	Daniell	Phil. Trans., 1844; Phil. Mag., 4, XXIV, 463; XXV, 175, 246; Arch. Elect., IV, 289; Pogg., LXIV. 18.	Electrol. of binary compounds.
	De la Rive	Arch. Elect., IV, 454.	Ozone by electrolysis.
	Desbordeaux	C. R., XIX. 1450.	Silver-plating.
	Elkington	Arch. Elect., IV, 515.	Electro-metallurgy.
	Fontaine-moreau	Br. Pat. Rep., 1844, 10282.	Electro-met. of alloys.
	Joule	Phil. Mag., 3, XXIV, 106.	Intermittent currents in electrolysis.
	Hull	Dingl. J., XCIV, 388.	Electrolysis of wine.
	Kobell	Arch. Elect., IV, 584.	Electro-metallurgy.
	Levol	C. R., XVIII, 708, 837.	Precipitation of metals.
	Louyet	" XIX. 1180.	Zinc-plating.
	Martens	Pogg. LXI, 121.	Passive iron.
	Matteucci	A. c. p., 3, XII. 122.	Electrolysis.
	Napier	Phil. Mag., 3, XXV, 379.	Electrolysis of double cyanides.
	Nouailher	Bull. Soc. l'Ind., XLIII, 54; XLV, 298.	Electro-metallurgy.
	Schönbein	Arch. Elect., IV, 333.	Ozone by electrolysis.
	Smee	" IV, 643.	Theory of electrolysis.
1845	Avogadro	A. c. p., 3, XIV, 330; Mem. Acad. Sci. Turin, II, VIII.	Electro-chemical series.
	Becquerel	C. R., XX, 1509; Arch. Elect., V, 233.	Electrolysis by terrestrial currents.
	"	A. c. p., 3. XIII, 216.	Electrolysis.
	Bietz	Pogg., LXIII. 415.	Passive iron.
	Christofle	C. R., XXI, 1382.	Electro-metallurgy.
	Church	Br. Pat. Rep., 1845, 11010.	Electrolysis of coke.
	Dechaud	C. R., XX, 1659, 1712; XXI, 278; Bull. Soc. l'Ind., XLIV, 207, 271.	Extraction of Cu from minerals.
	De la Rive	C. R., XX, 1291.	Ozone by electrolysis.

1845	De la Rive	Arch. Elect., V, 345; Chem. Soc. Mem., II, 300; Phil. Mag., 3, XXVII, 15; Am. J. Sci., 1, XLIX, 390.	Structure of metals deposited by electrolysis.
	Desbordeaux	C. R., XX, 103, 248, 353; XXI, 162.	Silver-plating.
	Jacobi	Arch. Elect., V, 184.	Electro-metallurgy.
	Hunt	Chem. Soc. Mem., II, 319.	Actinic influence on electrolysis.
	Millon	Arch. Elect., V, 303.	Electrolysis of water.
	Napier	Chem. Soc. Mem., II, 158, 255; Arch. Elect., V, 159; Phil. Mag., XXVI, 211.	Decomposition of double cyanides.
	Normand	Br. d'Inv., II, 248.	Gilding on silver.
	Parkes	Br. Pat. Rep., 1845, 10860; Rep. of Arts, VII, E. S., 358.	Electro-metallurgy.
	Perrot	C. R., XXI, 1328.	The same.
	Philippe	Bull. Soc. l'Ind., XLIV, 218; XLVII, 711.	The same.
	Rivier	Arch. Elect., V, 24.	Ozone by electrolysis.
	Pouillet	C. R., XX, 1544.	Electrolysis.
	Roseleur	Br. d'Inv., V, 123.	Gilding.
	Ruolz	C. R., XXI, 1437.	Electro-metallurgy.
	Schönbein	Pogg., LXV, 161; Arch. Elect., V, 11, 337; Br. A. A. Sci., 1845, 91.	Ozone by electrolysis.
	Soyer	Bull. Soc. l'Ind., XLIV, 88.	Electro-metallurgy.
	Tourasse	C. R., XXI, 378.	Mirrors silvered by electrolysis.
	Williamson	Chem. Soc. Mem., II, 305; Phil. Mag., XXVII, 372; Arch. Elect., V, 188.	Ozone by electrolysis.
1846	Barral	C. R., XXIII, 35.	Electro-gilding.
	Becquerel	" XXII, 781; Dingl. J., CI, 267.	Electrolysis of minerals.
	Boch	Bull. Soc. l'Ind., XLV, 97.	Electro-metallurgy.
	Boquillon	C. R., XXIII, 855.	The same.
	Hankel	Pogg., LXIX, 263.	Electrolysis of salts.
	Howell	Br. Pat. Rep., 1846, 11065; Pat. J., I, 179.	Electro-metallurgy of Pt.
	Hulot	Bull. Soc. l'Ind., XLVI, 572.	Electro-metallurgy.
	Lemercier	Br. d'Inv., VI, 209.	The same.
	Matteucci	A. c. p., 3, XVI, 257.	Electro-chemical action.
	Napier	Phil. Mag., 3, XXIX, 92.	Theory of electrolysis.
	Perrot	C. R., XXIII, 767.	Electro-metallurgy.
	Paget	Br. Pat. Rep., 1846, 11448; Rep. of Arts, X, 83, E. S.; Lond. J., XXX. C. S., 417; Pat. J. II, 885; Eng. & Arch. J., X, 292.	The same.
	Ramont	Br. d'Inv., VII, 131.	Electro-metallurgy of Ag.
	Woilley	C. R., XXII, 924.	Electrotyping.
	Wood	Sci. Amer., XII, 142.	Electro-metallurgy.
	Barral	C. R., XXV, 556, 602, 760.	Priority in electro-gilding.

1847	Becquerel	C. R., XXIV, 505.	Electrolysis.
	Bouquillon	" XXV, 207.	Priority in electrotyping.
	Boutellier	Br. d'Inv., XI, 201.	Electro-metallurgy of Ag.
	Coblentz	C. R., XXV, 28.	Electro-plating.
	Crosse	Br. Pat. Rep., 1847, 11604.	Electrolysis of liquors.
	Delaurie	C. R., XXIV, 975.	Precipitation of metals.
	De la Salzede	Br. Pat. Rep., 1847, 11878; Rep. of Arts, XI, E. S., 293; Lond. J., XXXII, C. S., 260; Pat. J., IV, 505; Eng. & Arch. J., XI, 169.	Electro-metal. of bronze.
	Garson	C. R., XXIV, 466.	Applications of electrol.
	Grove	Am. J. Sci., 2, IV, 411.	Effect of area of electrolyte.
	Kolbe	Ann. Pharm., LXIV, 236.	Electrol. of organic bodies.
	Kroening	C. R., XXV, 818.	Silk gilded.
	Maas	Bull. Ac. Sci., Brus., XIV, 2, 10.	Passive iron.
	Osann	Pogg., LXXI, 458; LXXII, 468.	Ozone by electrolysis.
	Perrot	C. R., XXV, 347, 428.	Priority in electro-gilding.
	Rochas	" XXV, 312.	Electro-plating.
	Ruolz	" XXV, 555, 602.	Priority in electro-gilding.
	Sainte-Preure	" XXIV, 1158.	Electro-gilding.
	Santayra	Br. d'Inv., XII, 334.	Electro-metallurgy.
	Woilley	C. R., XXV, 17.	The same.
1848	Clement	Br. Pat. Rep., 1848, 12335.	Electrolysis of sugar.
	Junot	Br. d'Inv., XIII, 1.	Electro-gilding.
	Napier	Chem. Soc. Mem., III, 47.	Theory of electrolysis.
	Osann	Pogg., LXXV, 386.	Ozone by electrolysis.
	Poitevin	C. R., XXVI, 346.	Electro-metal. of bronze.
	Rivot	Bull. Soc. l'Ind., XLVII, 356.	Electrolysis of minerals of Cu.
	Woilley	C. R., XXVI, 506, 573.	Electro-metallurgy.
	?	Bull. Soc. l'Ind., XLVII, 260.	Electro-metal. of bronze.
1849	Becquerel	A. c. p., 3, XXVII, 5; J. pr. Chem., XLVIII, 193; C. R., XXVIII, 650; JB., 1849, 201.	Theory of electrolysis.
	Bonis	C. R., XXIX, 403.	Electrolysis.
	Fontaine-moreau	Br. Pat. Rep., 1849, 12523; Mech. Mag., LI, 284; Pat. J., IX, 55.	Electro-metal. of brass.
	Kolbe	Ann. Chem. Ph., LXIX, 257, 279; J. pr. Chem., XLII, 311; JB., 1847, 558; 1849, 335.	Electrolysis of organic bodies.
	Parkes	Br. Pat. Rep., 1849, 12334; Rep. of Arts, XIV. E. S., 361; Mech. Mag., LI, 309; Pat. J., VIII, 42.	Electro-metal. of alloys.
	Poggendorff	Arch. ph. nat,, X, 133.	Electrolysis of bismuth.
	Poncil	Br. d'Inv., XIV, 213.	Gilding on zinc.

1849	Russell	Br. Pat. Rep., 1849, 12526; Rep. of Arts, XV, E. S., 163; Mech. Mag., LI, 285; Pat. J., IX, 70.	Electro-metallurgy of alloys.
	Schönbein	Pogg., LXXVIII, 289; Arch ph. nat., XIII, 192; JB., 1849, 201.	Theory of electrolysis.
	Smith	Br. Pat. Rep., 1849, 12654; Mech. Mag., LI, 571; Pat. J., VIII, 224.	Electro-metallurgy of Ag.
	?	Sci. Amer., V, 140.	Electrotyping.
1850	Avogadro	A. c. p., 3, XXIX, 248; Mem. Ac. Sci. Turin, 2, XI.	Electro-chemical series.
	Becquerel	C. R., XXXII, 83.	Electrolysis influenced by light.
	Brazier	Ann. Pharm., LXXV, 265; JB., 1850, 399.	Electrol. of organic acids.
	Lanaux	Br. d'Inv., XVI, 270.	Electro-metallurgy of Pt.
	Lefèvre	" XVIII, 313.	Electro-metallurgy.
	Matteucci	C. R., XXXII, 145.	Electrolysis of salts.
	Roseleur	Br. Pat. Rep., 1850, 13020; Mech. Mag., LIII, 250; Pat. J., IX, 296.	Electro-metallurgy of Sn.
	Steele	Br. Pat. Rep., 1850, 13216; Mech. Mag., LIV, 134; Pat. J., X, 220.	Electro-metall. of alloys.
	Ward	Rev. Sci., XXXIX, 34.	Electro-metallurgy.
1851	Becquerel	A. c. p., 3, XXXII, 645.	Electrol. effected by light.
	"	C. R., XXXIV, 29.	Minerals by electrolysis.
	Bouillet	A. c. p., 3, XXXIV, 153; C. R., XXXIII, 613; XXXIV, 193, 282.	Electrolysis of double cyanides.
	Brooman	Br. Pat. Rep., 1851, 13845.	Electrolysis of organic matter.
	Carptier	Br. d'Inv., XXIV, 178.	Electro-metallurgy.
	Cowper	Br. Pat. Rep., 1851, 13513; Mech. Mag., LV, 158; Pat. J., XI, 279.	Gutta-percha in electrotyping.
	Delamotte	Br. d'Inv., XXXIV, 167.	Electro silvering.
	Delisle	" XV, 70.	Electro-metallurgy.
	Fremy and Becquerel	C. R., XXXIV, 379; A. c. p., 3, XXXV, 62; J. pr. Chem., LVI, 124; Ann. Pharm., LXXXIV, 204; Phil. Mag., 4, III, 543; J. Chem. Soc., V, 272.	Electrolysis.
	Knoblouet	Rev. Sci., XXIX, 368.	Electro-metallurgy.
	Matteucci	A. c. p., 3, XXXIV, 281; C. R., XXXIII, 663.	Electro-chemical combinations.
	Palmer	Br. Pat. Rep., 1851, 13726; Mech. Mag., LVI, 197.	Gelatine moulds in electrotyping.
	Ruolz	C. R., XXXIV, 248.	Electrolysis of double cyanides.
	Thompson	Phil. Mag., 4, II, 429.	Mechanical theory of electrolysis.

1851	Thomas	C. R., XXXIV, 556, 580; Chem. Gaz., 1852, 415.	Electro-silvering.
	Vigau	C. R., XXXIV, 734.	Electrolysis of water.
	Watt	Br. Pat. Rep., 1851, 13750.	Separation of metals.
1852	Almeida	C. R., XXXVIII, 682; Instit., 1854, 119; J. pr. Chem., LXII, 129.	Electrolysis of salts.
	Becquerel	C. R., XXXV, 129, 647; A. c. p., 4, XXXVII, 385; Arch. ph. nat., XXI, 227, JB., 1852, 6.	Electrolysis of hydrogen.
	Bell	Br. Pat. Rep., 1852, 14185; Rep. of Arts, 21, E. S., 32; Mech. Mag., LVIII, 18.	Electrolysis of $H_2 SO_4$.
	Bunsen	Ann. Pharm., LXXXII, 137; Pogg., XCII, 648; JB., 1852, 362.	Electrolysis of Mg.
	Despretz	C. R., XXXVIII, 897; Arch. ph. nat., XXVI, 138; JB., 1852, 258.	Electrolysis.
	Elkington	Sci. Amer., VIII, 402.	Electrotypes.
	Erckmann	Br. d'Inv., XXIV, 307.	Metals applied to fabrics.
	Foucault	Arch. ph. nat., XXV, 180; Instit., 1854, III; C. R., XXXVII, 580; Phil. Mag. 4, VII, 426; JB., 1852, 258.	Electrolysis.
	Gmelin	Ann. Pharm., LXXXII, 289; Pharm. Centrl., 1852, 385.	Electrolysis in analysis.
	Helle	Br. d'Inv., XXII, 334.	Electro-silvering.
	Hulot	C. R., XXXV, 867.	Electro-metallurgy.
	Jamin	" XXXVIII, 390, 443; Instit., 1854, 91; Arch. ph. nat., XXV, 275, 380; Phil. Mag., 4, VII, 526; JB., 1852, 257.	Electrolysis of water.
	Junot	Br. Pat. Rep., 1852, 1183.	Electro-metall. of Cr and Mg.
	Leblanc	C. R., XXXVIII, 444; Instit., 1854, 92; JB., 1852, 257.	Electrolysis of water.
	Lebas	Br. d'Inv., XXII, 288.	Gilding on iron.
	Morris	" XXVIII, 50; Br. Pat. Rep., 1852, 1032.	Electro-metallurgy.
	Paradis	Br. d'Inv., XXII, 306.	The same.
	Petrie	Br. Pat. Rep., 1852, 14346.	The same.
	Power	Br. d'Inv., XXIII, 221, 224.	Electro-metallurgy of Ag.
	Ridgway	Br. Pat. Rep., 1852, 14080; Mech. Mag., LVII, 374.	Electro-metallurgy.
	Roberts	Br. Pat. Rep., 1852, 14198.	Electrolysis of sugar.
	Roux	Br. d'Inv., XXIV, 222.	Electro-metallurgy.
	Soret	C. R., XXXIX, 504; Instit., 1854, 92 and 322; Arch. ph. nat., XXVIII; A. c. p., 3, XLII, 257; JB., 1852, 256.	Electrolysis of Cu salts.

1852	Soret	C. R., XXXVIII, 445; Arch. ph. nat., XXV, 175, 263; Phil. Mag., 4, VII, 459; J. pr. Chem., LXII, 40; JB., 1852, 257.	Electrolysis.
	Symonds	Br. Pat. Rep., 1852, 996.	Cleaning metal surfaces.
	Viard	A. c. p., 3, XXXVI, 129; Arch. ph. nat., XXI, 230.	Electrol. of oxygen.
	Wall	Br. Pat. Rep., 1852, 576.	Electrolysis of H_2SO_4.
	Watson	" " 575.	Pigments by electrolysis.
	Becquerel	A. c. p., 3, XXXIX, 48.	Electrolysis of gases.
1853	"	C. R., XXXVI, 209; Bibl. Univ., N. S., I, 155; JB., 1853, 8.	Electrolysis of minerals.
	Bishop	Br. d'Inv., XXIX, 132.	Electro-metallurgy of Cu.
	Bolley	Sci. Amer., IX, 96; Chem. Gaz., 1853; 354; Pharm. J. Trans., XII, 231.	Electro-plating.
	Buff	Ann. Pharm., LXXV, 1; Arch. ph. nat., XXII, 344; Chem. Soc. Q. J., IV, 47; Am. J. Sci., 2, XV, 426; J. B., 1854, 280.	Laws of electrolysis.
	Bussey	C. R., XXXVI, 540.	Electrol. of Si, Ti, Mg.
	Davy	Bibl. Univ., N. S., 1, 165;	Preservation of ship-sheathing.
	Delamotte	Br. d'Inv., XXIX, 181; XXXII, 321.	Silvering.
	De Medeiros	Br. Pat. Rep., 1853, 1789.	Preservation of ship-sheathing.
	Fremy and Becquerel	Quart. J. Sci., V, 272; J. Pharm., XXXI, 320.	Electrolysis.
	Gore	Pharm. J. Trans., XIII, 21	Electro-metallic deposition.
	Gourlier	Br. d'Inv., XXVII, 332.	Electro-metallurgy.
	Grove	Phil. Mag., 4, V, 201.	Electrolysis of salts.
	Guthrie	Arch. ph. nat., XXII, 371; Ann. Pharm., XCIX, 64; JB., 1853, 573.	Electrolysis of organic bodies.
	Hittorf	Pogg., LXXXIX, 177; JB., 1854, 279.	Electrolysis.
	Hulot	C. R., XXXVII, 409.	Electro-metallurgy.
	Kard	Phil. Mag., 4, VI, 241.	Electrolysis of water.
	Massé	Br. d'Inv., XXIX, 185.	Electro-silvering.
	Masson	" XXXIII, 144; Phil. Mag., 4, VI, 457.	Electro-metallurgy of Au.
	Muüs	Br. d'Inv., XXXI, 154.	Electro-metallurgy.
	Nickles	Arch. ph. nat., XXIV, 79; C. R., Aug., 1853.	Passive Ni and Co.
	Pershouse	Br. Pat. Rep., 1853, 2379.	Electro-metal. of alloys.
	Prax	Br. d'Inv., XXVIII, 412.	Electro-gilding.
	Shepard	Br. Pat. Rep., 1853, 1591.	Electrolysis of water.
	Tournière	" " " 1641.	Manufacture of $Na_2 CO_3$.
	?	J. Fr. Inst., 3, XXVI, 137.	Electro-plating on china.
	?	Sci. Amer., IX, 21.	Electrotyping.

1854	Almeida	C. R., XXXVIII, 682; Arch. ph. nat., XXIX, 5; JB., 1855, 229.	Electrolysis of salts.
	Becquerel	C. R., XXXVIII, 1095; Chem. Gaz., 1854, 359; Arch. ph. nat., XXVI, 270; Dingl., J., CXXXIII, 213.	Electrolysis of minerals of Ag, Pb, Cu.
	"	C. R., XXXVIII, 757; Phil. Mag., 4, VIII; Am. J. Sci., 2, XVIII, 382.	Electrolysis in chemical action.
	Black	Dingl. J., CXXXII, 31.	Electrolysis.
	Bocquet	Br. d'Inv., XXXV, 293.	Electro-metallurgy of Cu.
	Boucher	" XL, 94.	" " " Zn.
	Buff	Ann. Pharm., LXXXV, 1; J. Chem. Soc., VI, 54.	Laws of electrolysis.
	"	Ann. Pharm., LXXXVIII, 117; Instit., 1854, 80; JB., 1854, 281.	The same.
	Bull	Arch. ph. nat., XXV, 65; Ann. Pharm., LXXXVII, 117.	Electrolytic researches.
	Bunsen	Pogg., XCI, 619; A. c. p., 3, XLI, 354; J. Pharm., 3, XXV; JB., 1854, 320,	Electrol. of Mn and Cu.
	"	C. R., XLI, 717; Pogg., XCII, 648; J. Pharm., 3, XXVI, 311; Dingl. J., CXXXIII, 273.	Electrolysis of the alkaline earths.
	Callau	Phil. Mag., 4, VII, 73; J. Fr. Inst., 3, XXVIII, 203, 336.	Electrolysis of water.
	Coblence	C. R., XXXIX, 846.	Electro-metallurgy.
	Connell	Phil. Mag., 4, VII, 426.	Electrolysis of water.
	Daniel	Pogg. LXIV, 18; JB., 1854, 278.	Electrolysis of salts.
	De la Rive	Arch. ph. nat., XXV, 275.	Electrolysis of water.
	Denny	Br. Pat. Rep., 1854, 478.	Electro-metallurgy of Cu.
	Dida	Br. d'Inv., XXXIX, 79.	" " " Zn.
	Dumas	C. R., XXXVIII, 444.	Electrolysis of water.
	Foucault	Arch. ph. nat., XXIV, 268; Instit., 1854, 36; JB., 1854, 281.	Electrolysis.
	"	C. R., XXXVII, 580; Instit., 1853, 349; JB., 1854, 281.	Theory of electrolysis.
	"	Arch. ph. nat., XXV, 180.	Electrolysis of water.
	Gervaisot	Br. d'Inv., XXXIV, 248.	Electro-metallurgy
	Gore	J. Fr. Inst., 3, XXVII, 353; J. Pharm., 3, XXV, 475.	Electrolysis of Al and Si.
	Gmelin	Pogg., XLIV, 27; JB., 1854, 278.	Electrolysis of salts.
	Harrison	Br. Pat. Rep., 1844, 1714.	Pigments by electrolysis.
	Jamin	C. R., XXXVIII, 390, 443; Phil. Mag., 4, VII, 298; Arch. ph. nat., XXV, 380.	Electrolysis of water.
	Johnson	Br. Pat. Rep., 1854, 1471.	Electro-metallurgy of Cu.
	Leblanc	C. R., XXXVIII, 444; Phil. Mag., 4, VIII, 237.	Electrolysis of water.

1854	Lenoir	Br. d'Inv., XXXVIII, 119; XXXIV, 340.	Electro-metallurgy.
	Marignac	A. c. p., 3, XXXVIII, 148; J. Chem. Soc., 1854, 260.	Heat in electrolysis.
	Matteucci	C. R., XXXIX, 258.	Electrol. in chem. action.
	Meideck	Br. d'Inv., XXXVIII, 186.	Electro-metallurgy.
	Meidinger	J. Chem. Soc., VII, 251.	Ozone in electrolysis. of H_2SO_4.
	Osann	J. de Pharm., XXVI, 68.	Electrolysis of oxygen.
	Peyraud	Br. d'Inv., XXXIII, 1.	Electro-silvering.
	Person	" XXXIV, 122.	Electro-metallurgy of Zn.
	Regnault	C. R., XXXIX, 847.	Gutta-percha in electrotyping.
	Soret	C. R., XXXIX, 504; A. c. p., 3, XLII, 257; Arch. ph. nat., XXVII, 113.	Electrolysis of Cu salts.
	"	Arch. ph. nat., XXV, 175, 263; Ann. Pharm., LXXXVIII, 57.	Electrolysis of water.
	Toussaint	Br. d'Inv., XXXVI, 324.	Electro-metallurgy.
	Van Breda	Phil. Mag., 4, VIII, 465.	Electrolysis of liquids.
	Vergnes and Poey	C. R., XL, 235, 832, 961; Arch. ph. nat., XXVIII, 208; Sci. Amer., XI, 251.	Extraction of metallic particles in the organism by electrolysis.
	Viard	A. c. p., 3, XLII, 5; Arch. ph. nat., XXVII, 308.	Electrolysis of oxygen.
	Wagstaffe	Br. Pat. Rep., 1854, 1653.	Electrolysis of ores.
	?	Arch. ph. nat., XXVI, 134.	Electrolysis of water.
1855	Becquerel	C. R., XL, 1344; A. c. p. 3, XLIV, 401; Arch. ph. nat., XXX, 70.	Electrolysis of liquids in motion.
	"	C. R., XLI, 733.	Electrolysis in the earth.
	Beetz	Pogg. XCIV, 194.	Electrolysis.
	Briant	Chem. Gaz., 1850, 153.	Electro-metallurgy.
	Bory	Br. d'Inv., XLVIII, 230.	Electro-gilding.
	Buff	Ann. Pharm., XCVI, 257; Arch. ph. nat., XXXI, 198; JB., 1853, 233.	Electrolysis of water.
	"	Ann. Pharm., XCIV, 1, 22; Arch. ph. nat., XXIX, 118; JB., 1855, 232.	Electrolysis of salts.
	"	Ann. Pharm., XCIII, 256.	Electrolysis of water.
	Canot	Br. d'Inv., XLVIII, 29.	Electro-gilding.
	Chaudron	" XLIX, 335.	Baths for electro-metall.
	Decq	" XLV, 259.	Electro-metallurgy of Ag.
	Deiss	" XLIV, 329.	Electro-metallurgy of Zn.
	Derincenzi	C. R., XLI, 782, 1226.	Electrotyping.
	Elkington	Br. Pat. Rep., 1855, 1543.	Electro-metallurgy.
	Fremy	C. R., XL, 966; Chem. Gaz., 1855, 207.	Electrolysis of fluorides.
	Gaugain	C. R., Dec. 24, 1855.	Polarization of electrodes.
	Gedge	Br. Pat. Rep., 1855, 1956.	Electro-metallurgy.
	Gore	Pogg., XCV, 173; Phil. Mag., 4, IX, 73; J. Pharm., 3, XXVII, 283; JB., 1855, 382.	Electrolysis of Sb.

1855	Gore	Pharm. J., Trans., XIV, 464, 507; XV, 21, 59, 105, 154.	Rules of electro-metallurgy.
	Gueyton	C. R., XL., 1230.	Electro-metallurgy.
	Haltheisen	Ann. Pharm., XCIV, 107; JB,, 1855, 324.	Electrolysis of Li.
	Hulot	C. R., XLI, 156.	Electro-metallurgy.
	Johnson	Br. Pat. Rep., 1855, 18.	Electro-metallurgy of Cu.
	Jewreinoff	Chem. Gaz., 1855, 458.	Electro-metallurgy of Pt.
	Landois	C. R., XLI, 178; Br. d'Inv., XLVIII, 238.	Electro-gilding.
	Lesieur	Br. d'Inv., XLII, 312.	Electrotyping.
	Matthiessen	J. Chem. Soc., VIII, 27; Ann. Pharm., XCIII, 277; A. c. p., 3, XLIV, 60, 401; J. Pharm., 3, XXVII, 475; Chem. Gaz., 1855, 232; J. pr. Chem., LXIV, 508; Chem. Soc. Q. J., VIII, 294; JB., 1855, 323.	Electrolysis of the alkaline metals.
	Osann	Pogg., XCV, 311.	Electrolysis of hydrogen.
	Oudry	Br. d'Inv., LII, 356.	Electro-metallurgy.
	Pilloy	" XLV, 252.	Electro-metallurgy of Cu.
	Petiejean	" XLIX, 340.	Electro silvering on glass.
	Rigondeau	" XLVIII, 225.	Electro-gilding
	Riemann	Pogg., XCV, 130.	Theory of Nobili's rings.
	Soret	Phil. Mag., 4, X, 210; Arch. ph. nat., XXIX, 265; C. R., XLI, 220.	Laws of electrolysis.
	Souchier	Br. d'Inv., XLIV, 301.	Electro-metallurgy.
	Schönbein	J. pr. Chem., LXV, 129.	Electrolysis.
	Tailfer	Br. d'Inv., XLVII, 221.	Electro-metallurgy.
	Taylor	Br. Pat. Rep., 1855, 1997.	Electro-metallurgy of Al.
	Thomas	" " 1855, 253; 2756.	Electro-metal. of alloys.
	Vannier	Br. d'Inv., XLIII, 265.	Electro-gilding.
	Watt	Br. Pat. Rep., 1855, 272.	Electro-metallurgy of Zn.
1856	Andrews	Rep. Br. Assoc., 1855; Pogg., XCIX, 493; Instit., 1856, 369; A. c. p., 3, L, 124; JB., 1856, 244.	Electrolysis of water.
	Becquerel	C. R., XLII, 621.	Electro-metallurgy.
	"	Arch. ph. nat., XXXV, 231; C. R., XLIII, 1101.	Electrolysis with weak currents.
	Beetz	Pogg., XCVII.	Theory of Nobili's rings.
	Beslay	C. R., XLIII, 657, 853.	Autotypes.
	Buff	Ann. Ch. Pharm., CI, 1; Arch. ph. nat., XXXIV, 204; JB., 1856, 244.	Electrol. of chromic acid.
	Burel	Br. Pat. Rep., 1856, 734.	Manuf. of Prussian blue.
	Calvert	" " 1856, 3.	Electrolysis of ores.
	Cowper	" " 1856, 2992.	Electro-metallurgy of Cu.
	Chailley	Br. d'Inv., LVII, 435.	Electro-gilding.
	De la Rive	Pogg. XCIX, 626; C. R., XLII, 710.	Electrolysis of water.

1856	Delmas	Br. d'Inv., LIV, 394.	Electro-metal. of gold.
	Despretz	C. R., XLII, 707.	Electrolysis of water.
	Dufresne	Br. d'Inv., LV, 141.	Electro-gilding and silvering.
	Gaensly	" LVII, 428.	Electro-gilding.
	George	C. R., XLIII, 20.	Electro-metallurgy.
	Geuther	Ann. Pharm., XCIX, 314; Arch. ph. nat., XXXIII, 228; JB., 1856, 243.	Electrol. of chromic acid.
	Gore	J. Pharm., 3, XXIX, 363; Pharm. J. Trans., XV, 357.	Electrolysis of Fe and Sn.
	Guérin	C. R., XLIII, 808; Arch. ph. nat., XXXIV, 232.	Electro-gilding.
	Gueyton	C. R., XLII, 492, 511.	Electro-metallurgy.
	Guthrie	Ann. Pharm., XCIX, 64.	Electrolytic experiments.
	Hamel	Br. d'Inv., LV, 62.	Electro-metallurgy.
	Hittorf	Pogg. XCVIII, 1, 177.	Analysis by electrolysis.
	Kolrausch	Pogg., XCVII, 397, 559; JB., 1856, 239.	Measure of electrolytic force.
	Lautépin	Br. d'Inv., LVI, 84.	Silvering on wood.
	Lenoir	C. R., XLII, 415, 476, 618; Arch. ph. nat., XXXII, 219.	Electro-metallurgy.
	Magnus	Berl. Acad. Ber., 1856, 188; C. C., 1856, 338; J. pr. Chem., LXVIII, 54; Phil. Mag., 4, XII, 157; Arch. ph. nat.. XXXII, 327; JB., 1856, 239.	Electrolytic investigations.
	Osann	J. pr. Chem., LXVI, 253; Pogg. XCVI, 498; XCVII, 327; Arch. ph. nat., XXXI, 342.	Gypsum moulds in electrotyping.
	Oudry	Br. d'Inv., LIV, 219; C. R. XLII, 1144, 1174; XLIII, 42, 110.	Electro-metallurgy of Fe.
	Regnault	C. R., XLVI, 852.	Electrolysis of Mg.
	Schönbein	Pharm. J. Trans., XV, 513.	Heat and electrolysis.
	Sorel	A. c. p., 3, XLV, 11, 119.	Electrolysis of water.
	Soret	Arch. ph. nat., XXXI, 204.	The same.
	Van Breda	Arch. ph. nat., XXXIII, 5; Pogg., C, 149; JB., 1856, 239.	Electrolysis.
	Wiedemann	Pogg., XCIX, 177; Arch. ph. nat., XXXIII, 177.	Electrolysis of salts.
	Willigen	Pogg., XCVIII, 511; A. c. p., L, 126.	Ozone by electrolysis.
	?	J. pr. Chem., LXVII, 173.	Electrolysis of water.
	?	J. Fr. Inst., 3, XXXI, 412.	Photo-galvanic process.
	?	" 3, XXXI, 115.	Electro-chem. engraving.
1857	Almeida	A. c. p., 3, LI, 257.	Electrolysis of salts.
	Baumert	Ann. Pharm., CI, 88.	Ozone by electrolysis.
	Becker	Br. Pat. Rep., 1857, 1274.	Silvering organic bodies.
	Becquerel	C. R., XLIV, 938.	Electrolysis with weak currents.

1857	Berlin	C. R., XLIV, 1273; XLV, 82.	Platinum electrodes.
	Bosscha	Pogg., CI, 517; CIII, 487; CV, 396; A. c. p., 3, LXV, 367; Arch. ph. nat. [N. P.] 1, 361.	Mechanical theory of electrolysis.
	Breda	Pogg. XCIX, 634.	Electrolysis of water.
	Carpentier	Br. d'Inv., XXXIV, 407.	Electro-metallurgy.
	Clausius	Pogg., CI, 338.	Condition of electrolytes.
	Coulson	Br. Pat. Rep., 1857, 2074.	Electro-metal. of Au.
	Cowper	" " 1857, 1180.	Electro-metallurgy.
	Despretz	C. R., XLV, 449.	Electrolysis of Pb. salts.
	"	" XLIV, 1009; Phil. Mag., 4, XIV, 75.	Electrolysis.
	Dupré	Arch. ph. nat., XXXV, 98.	Electrolysis of salts.
	Garnier	Br. d'Inv., LXI, 174.	Electro-metallurgy.
	Geuthier	Am. J. Sci., 2, XXVIII, 281.	Electrolysis of waters.
	Gorde	Br. P. Rep., 1857, 887.	Electro-metal. of alloys.
	Hittorf	Pogg., CIII, 1; JB., 1857, 27.	Analysis by electrolysis.
	Kobell	J. pr. Chem., LXXI, 146; Chem. Gaz., 1857, 437.	Electrol. of chromic acid.
	Magnus	Pogg., CII, 1; Ann. Pharm., 3, LII, 345; Arch. ph. nat., XXXVI, 350; Cimento, VII, 56; C. C., 1857, 954; JB., 1857, 53; Am. J. Sci., 2, XXV, 98; A. c. p., CI, 212.	Electrolysis of salts.
	Miller	Br. A. A. Sci., 1851, 158.	Researches in electrolysis.
	Moigno	Edinb. N. Phil. J., N. S., VI, 306.	Electrotypes.
	Newly	Br. Pat. Rep., 1857, 3115.	Electro-metallurgy of Sn.
	Noualhier	" " 1857, 5.	Electro-metallurgy.
	Palagi	Br. d'Inv., LXIII, 219.	Gilding on wood.
	Peil	Chem. Gaz., 1857, 220.	Shellac moulds in electrotyping.
	Schlagdenhauffen	J. Pharm., 3, XXXI, 410; JB., 1857, 57.	Electrolysis of salts.
	Sinsteden	Pogg., CI, 1.	Electrolysis by magneto-electricity.
	Walenn	Br. Pat. Rep., 1857, 1840.	Electro-metall. of alloys.
1858	Beslay	Br. d'Inv., LXVIII, 264; Br. Pat. Rep., 1859, 103.	" of Zn, Sn, Pb.
	Böttger	Pogg., CIV, 292; J. pr. Chem., LXXIII, 484; Repert. Chim., I, 56.	Electrolysis of Sb.
	"	J. pr. Chem., LXXIII, 494.	$H\ NO_3$ by electrolysis.
	Brionde	Br. d'Inv., LXVI, 206.	Gilding on zinc.
	Buff	Ann. Pharm., CV, 145; A. c. p., 3, LIX, 117.	A study of electrolytes.
	"	Ann. Pharm., CVI, 203.	Movements in the electrolyte.
	Clausius	Pogg. CIII, 525; Phil. Mag., 4, XIV, 94; JB., 1858, 27.	Electrolysis.

1858	Corbelli	Br. Pat. Rep., 1858, 507.	Electro-metallurgy of Al.
	Fonvielle	C. R., XLVII. 149.	Electrolysis of water.
	Gore	Phil. Mag., 4, XVI, 441; JB., 1858, 177.	" of Sb.
	Grove	Phil. Mag., 4, XVI, 426.	Light and electrolysis.
	Jacquin	Br. P. Rep., 1856, 667.	Electro-metallurgy of Fe.
	Kérikuff	C. R., XLVII, 334.	Electrolysis of alkaline solutions.
	Liebig	Br. d'Inv., LXVI, 405.	Electro-plating on glass.
	Linnemann	J. pr. Chem., LXXIII, 415; JB., 1858, 116.	Electrolysis of K.
	Magnus	Pogg., CIV, 553.	Indirect electrolytic action
	Munro	Br. d'Inv., LXIX, 445.	Electro-metallurgy of Sn.
	Nezeraux	" LXVI, 206.	Electro-metallurgy.
	Osann	Pogg., CIII, 616; C. C., 1858, 145; JB., 1858, 25.	Electrolysis of salts.
	Perrot	C. R., XLVI, 180; XLVII, 351; Arch. ph. nat., [N. P.], I, 278.	Effect of electric spark on alcohol and water vapor.
	Quit	C. R., XLVI, 903; Arch. ph. nat., [N. P.], II, 262.	Electrolysis of gases by the spark.
	Regnault	Arch. ph. nat., [N. P.], II, 160; C. R., XLVI, 852.	Electro-chemical equivalent of Mg.
	Riche	C. R., XLVI, 348; Phil. Mag., 4, XV, 328.	Electrolysis of Br, CI, I.
	Shepard	Br. Pat. Rep., 1858, 353.	Electro-metallurgy of Ag.
	Weiske	Pogg., CIII, 466; JB., 1858, 27.	Chlorine by electrolysis.
	Wiedemann	Pogg. CIV, 162; JB., 1858, 27.	Electrolysis.
	Wiedemann	Pogg., XCIX, 177; A. c. p., 3, LII, 224.	Motion of liquids in electrolysis.
	Wild	Pogg. CIII, 254; Arch. ph. nat., [N. P.], II, 378.	Electrolysis of concentrated solutions.
	Wittich	J. pr. Chem., LXXIII, 18; JB., 1858, 541.	Electrol. of organic bodies.
	?	Sci. Amer., XIV, 4.	Electrolysis.
1859	Barre	Br. d'Inv., LXXIII, 182.	Decoration by electro-metallurgy.
	Becquerel	Mem. de l'Ac., XXVII, 2°.	Electrolysis by weak currents.
	Brewster	JB., 1859, 86.	Electrol. of organic acids.
	Bosscha	Pogg., CVIII, 312.	Heat in electrolysis.
	"	Pogg., CV, 396; Arch. ph. nat. [N. P.], VII, 137.	Mechanical theory of electrolysis.
	Bradbury	J. Fr. Inst., 3, XXXVII, 344.	Electro-metallurgy of Zn.
	Buff	Ann. Pharm., CX, 257; C. C., 1859, 686; Phil. Mag., 4, XVIII, 394; A. c. p., 3, LIX, 120; JB., 1859, 35; Chem. News, II, 23; Arch. ph. nat. [N. P.], IX, 134.	Electrolysis of the higher compounds.
	Clausius	Arch. ph. nat. [N. P.], IV, 242.	Study of electrolytes.

1859	Friedel	Ann. Pharm., CXII, 376.	Electrolysis of water.
	Geuther	" CIX, 129; JB. 1859, 82; Chem. Gaz., 1859, 285; Arch. ph. nat. [N. P.], V, 72.	" of H_2SO_4.
	Hittorf	Pogg., CVI, 337, 513.	Electrolysis.
	Meydinger	J. Pharm., 3, XXXVI, 76.	Electro-metallurgy.
	Morren	C. R., XLVIII, 342.	Electrolysis of gases.
	Newton	Br. Pat. Rep., 1859, 1045.	Nitric acid by electrol.
	Perrot	C. R., XLIX, 37; Arch. ph. nat. [N. P.], IV, 186; V, 267; Phil. Mag., Dec., 1858.	Electrodes in sulphate of copper voltameters.
	"	C. R., XLIX, 204; Arch. ph. nat. [N. P.], VI, 66.	Electrolysis by the spark.
	Schmidt	Pogg., CVII, 556.	Electrolysis of H_2SO_4.
	Schönbein	J. pr. Chem., LXXVIII, 63; Pogg. Ann., CVIII, 471; A. c. p., LVIII, 484.	Polarization of oxygen during electrolysis.
	Wiedemann	Pogg., XCIX, 231.	Electrol. of binary salts.
	?	J. Fr. Inst., 3, XXXVIII, 124.	Durability of electrotypes.
	?	J. Fr. Inst., 3, XXXVII, 344.	Electro-metallurgy of Zn.
	?	Sci. Amer., 2, I, 275.	Electrotyping by lightning.
	?	Rep. Chim. App., I, 419.	Gutta-percha in electrotyping.
1860	Almeida	C. R., LI, 214; Chem. News, II, 144.	Electrolysis of a mixture of HNO_3 and alcohol.
	Bethnoud	U. S. Pat. Rep., 1860, 30663.	Electro-metall. of alloys.
	Buff	Arch. ph. nat. [N. P.], IX, 107.	Electrolytic studies.
	Coleman	Chem. News, I, 242.	" apparatus.
	E. G.	" I, 204, 216.	Electrol. of nitrogen compounds.
	Gore	Phil. Mag., 4, XXII, 555; Arch. ph. nat. [N. P.], VIII, 323.	Musical sounds by electrolysis.
	Grove	Phil. Mag., 4, XX, 126; A. c. p., 3, LXI, 156; Arch. ph. nat. [N. P.], VIII, 330.	Transmission of electrolysis across glass.
	Hoffmann	J. Chem. Soc., XII, 273.	Electrolysis of gases.
	Hughes	Br. Pat. Rep., 1860, 1385.	Electro-metall. of alloys.
	Kolbe	Ann. Pharm., CXIII, 244; JB., 1860, 245.	Electrolysis of organic bodies.
	Lerret	C. R., L, 560.	Electro-metallurgy.
	Person	Chem. News, II, 275.	Electro-metallurgy of Zn.
	Perrot	Arch. ph. nat. [N. P.], XI, 232; A. c. p., 3, LXI, 161.	Electrolysis by the induction spark.
	Piffard	Chem. News, II, 323; Sci. Amer., 2, V, 200.	Electrotyping.
	Saint-Victor	C. R., L, 440.	Electrol. of Au and Ag.
	Smee	Chem. News, I, 31.	Detection of As.
	Spigerel	Br. d'Inv., LXXVIII, 271.	Electro-silvering.

1860	Wright	Phil. Mag., 4, XIX, 129.	Mercury as an electrode.
1861	Abel	Br. Pat. Rep., 1861, 1792.	Electro-metallurgy of Ni.
	Andrews	J. Chem. Soc., XIII, 344.	Electrolysis of oxygen.
	Becquerel	C. R., LIII, 1196; JB., 1861, 203.	Hydrates of Si and Al by electrolysis.
	"	Chem. News, IV, 5.	Coloring iron by electrol.
	Bell	Br. Pat. Rep., 1861, 1214.	Electro-metallurgy of Al.
	Bloxam	J. Chem. Soc., XIII, 12.	Detection of As and Sb.
	Brooman	Br. Pat. Rep., 1861, 2023.	Electro-metallurgy of Au.
	Gerardin	C. R., LIII, 727; JB., 1861, 51.	Electrolysis of alloys.
	Lapschin and Tichanowitsch	Peters. Acad. Bull. [N. S.], IV, 81; C. C., 1861, 613; Phil. Mag., 4, XXII, 308; J. Pharm., 3, XLI, 95; JB., 1861, 50.	Electrolysis with large batteries.
	Marié	C. R., LIII, 1058.	Electrol. of alkaline salts.
	Piffard	Chem. News, IV, 110.	Electro-metallurgy.
	Planté	C. R., L, 393.	Electrolysis.
	Von Liebig	U. S. Pat. Rep., 1861, 33721.	Electro-metallurgy of Cu.
	Wake	Chem. News, III, 365.	Electro-metallurgy.
	?	Sci. Amer., 2, V, 361.	Electro-plating.
	?	J. Fr. Inst., 3, XLII, 330.	Coloring iron by electrol.
	?	Sci. Amer., 2, V, 342.	Electro-plating iron.
1862	Becquerel	C. R., LV, 18; Instit., 1862, 221; Arch. ph. nat. [N. P], XV, 59; Rep. ch. pure, IV, 321; C. C., 1862, 772; J. pr. Chem., LXXXVI, 503; Ann. Pharm., CXXIV, 311; Dingl. J., CLXV, 373; Zeitschr. Chem. Pharm., 1862, 478; JB., 1862, 34; Chem. News, VI, 126.	Electrolysis by weak currents.
	Beetz	Pogg., CXVII, 17.	Electrolysis of H_2 SO_4.
	Beslay	U. S. Pat. Rep., 1862, 36750.	Electro-metallurgy.
	Dickson	Br. Pat. Rep., 1862, 2044, 2266.	Manuf. of Na_2 CO_3.
	Garnside	Dingl. J., CLXVI, 309.	Electrotyping.
	Gore	JB., 1862, 162.	Electrolysis of Sb.
	"	Proc. Roy. Soc., 1862; Phil. Mag., 4, XXIV, 461; Arch. ph. nat. [N. P.], XV, 64.	Sound by electrolysis.
	Miller	U. S. Pat. Rep., 1862, 34640.	Electro-plating wires.
	Quncke	Arch. ph. nat. [N. P], XIII, 185.	Electrolysis.
	Walcott	U. S. Pat. Rep., 1862. 34470.	Electro-metallurgy of Cu.
1863	Abel	J. Chem. Soc., XVI, 235; Chem. News, VIII, 18.	Electrolytic action.
	Baeyer	Ann. Pharm., CXXVII, 38.	Ozone by electrolysis.
	Becquerel	C. R., LVI, 237; Instit., 1863, 41; Ann. Pharm., CXXVI, 298; C. C., 1863, 525; JB., 1863, 115; Chem. News, VII, 219.	Electrolysis of insoluble compounds.
	Bonsfield	Chem. News, VII, 69.	Electro-metallurgy.

1863	Dircks	Chem. News, VII. 105.	History of electro-metall.
	Gore	Phil. Mag., 4, XXV, 479; JB., 1863, 232; J. Chem. Soc., XVI, 365; Chem. News, VIII, 257. 281.	Electrolysis of Sb.
	Gerardin	C. R., LIII, 727; Instit., 1861, 378; Rep. chim. pure, IV. 49; JB., 1863, 52.	Electrolysis of K and Na.
	Kirchner	C. C., 1863, 837; JB., 1863, 502.	Electrolysis of glycerine.
	Lovel	C. R., LVI, 390.	Ozone by electrolysis.
	Moigno	Br. A. A. Sci., 1863, 20.	Electro-metallurgy of Cu.
	Perrot	A. c. p., 3. LXI, 161; Arch. ph. nat. [N. P.], XI, 232; JB., 1863, 52.	Electrolysis by the induction spark.
	Soret	C. R., LIV, 390; Bibl. Univers., XVI; J. pr. Chem., XC, 216; Ann. Pharm., CXXVII, 38; Pogg., CXVIII, 623; Roma, Atti, XVI, 638; Phil. Mag., 4, XXV, 208; Chem. News, VII, 248; Arch. ph. nat. [N. P.], XVI, 208.	Ozone by electrolysis.
	Werther	J. pr. Chem., LXXXVIII, 151; JB., 1863, 502.	Electrolysis of glycerine.
1864	Becquerel	C. R., LIX, 521.	Electro-chem. equivalents.
	Edme	Chem. News, X, 91.	Electrolysis of oxygen.
	Jaillard	Ann. Pharm., CXXXII, 360; C. R., LVIII, 1203.	Electrolysis of alcohols.
	Kekulé	Ann. Pharm., CXXXI, 80; JB., 1864, 374; Bull. Soc. Chim., I. 242.	Electrol. of organic bodies.
	Martin	C. R., LVIII, 108.	Theory of electrolysis.
	Moore	Br. Pat. Rep., 1864, 2029.	Electro-metallurgy of Au.
	Raoult	C. R., LIX, 521; A. c. p., 4, IV, 417; Phil. Mag., 4, XXVIII, 551; JB., 1864, 116.	Heat and electrolysis.
	Soret	Arch. ph. nat. [N. P.], XX. 324; C. R., LIX, 485; Instit., 1864, 316; Phil. Mag., 4, XXVIII, 563; A. c. p., 4, III, 504; JB., 1864. 116.	Electrolysis of gases.
	Thompson	Br. Pat. Rep., 1864, 3095.	Electro-metallurgy of Pt.
	Weil	" " 1864, 497; A. c. p., 4, IV, 374; C. R., Nov., 1864; Quart. J. Sci., 1, II, 130; Bull. Soc. Chim., II. 472.	New process of electro-metallurgy.
	?	Dingl. J., CLXXII, 433.	Electrolysis.
	?	J. Fr. Inst., 3, XLVII, 261.	Curious electrolytic action.
1865	Berlandt	Arch. Pharm., CXXI, 54; Phil. Mag., 4. XXX, 451.	A new electrolytic process.
	Buff	Ann. Pharm., XCIV, 15.	Electrolysis of Ag Cl.

1865	Canderan	Dingl. J., CLXXV, 134; CLXXVIII, 204.	Electrolysis.
	Gibbs	Bull. Soc. Chim., VI, 126; Am. J. Sci., 2, XXXIX, 64.	Analysis of Cu and Ni.
	Hittorf	Pogg., CXXVI, 195; Phil. Mag., 4, XLVIII, 240.	Electrolysis of P.
	Martin	C. R., LX, 777, 956; Quart. J. Sci., 1, II, 50.	Theory of electrolysis.
	Reid	Chem. News, XII, 242; JB., 1865, 243.	Electrolysis of Th.
	Renault	Bull. Soc. Chim., IV, 119.	Analysis of alloys.
	Smith	Sci. Amer., 2, XIII, 404.	Electro-plating of steel springs.
	Thompson	Br. Pat. Rep., 1865, 2592.	Electro-metallurgy of Fe.
	Ullik	Wien. Akad. Ber., LII, 2°, 115; JB., 1865, 186.	Electrolysis of Si.
	Viollet	B. Soc. l'Ind., 2, XII, 447, 753.	Electro-metallurgy of Cu.
	Well	Sci. Amer., 2, XII, 182.	Electro-plating.
	Zaliwski	C. R., LXI, 945.	Electrolysis.
	?	Pogg., CXXIV, 75.	Electrol. of organic bodies.
	?	" CXXV, 57.	Electrolysis.
	?	Chem. News, XII, 3; Cosmos, 2, I, 595.	Metalloids by electrolysis.
	?	Chem. News, XI, 60.	Electro-metallurgy.
1866	Brewster	Bull. Soc. Chim., VIII, 23; Arch. Neer. Sci. Ex., I, 296.	Electrolysis.
	Bouilhet	B. Soc. l'Ind., 2, XIII, 207.	Electro-metallurgy.
	Bourgoin	A. c. p., 4, XIV, 157; Chem. News, XVI, 313; C. R., LXV, 892, 998, 1144; JB., 1867, 381.	Electrol. of organic bodies.
	Brewster	JB., 1866, 87.	The same.
	Brooman	Br. Pat. Rep., 1866, 3047.	Electro-metal. of bronze.
	Christofle	B. Soc. l'Ind., 2, XIII, 389.	Electro-metallurgy.
	Heeren	Sci. Amer., 2, XIV, 357.	Electrotyping.
	Lean	Quart. J. Sci., 1, III, 300.	Electrolysis of CO_2.
	Leu	Bull. Soc. Chim., VI, 96.	Gelatine in electro-metall.
	Planté	C. R., LXIII, 181.	Ozone by electrolysis.
	St. Edne	J. pr. Chem., XCIV, 507.	The same.
	?	Pogg., CXXVII, 45.	Electrodes of Al and Mg.
1867	Balsamo	C. R., LXV, 613.	Electro-metallurgy.
	Bartlett	Chem. News, XVI, 257.	Experiments in electrol.
	Becquerel	C. R., LXIV, 919, 1211; LXV, 51, 720, 752; Instit., 1867, 155, 193, 353; Zeitsch. Chem., 1867, 374, 455, 515; Arch. ph, nat. [N. P.], XXIX, 55; J. Pharm., 4, VI, 129; JB., 1867, 111.	Electro-capillarity in electrolysis.
	Bouilhet	B. Soc. l'Ind., 2, XIV, 377, 409.	Electro-gilding.

1867	Buff	Chem. News, XV, 279; Ann. Pharm., Sup. IV, 257; JB., 1866, 83.	Electrolysis of alkaline sulphates.
	Feuquieres	B. Soc. l'Ind., 2, XIV, 539.	Electro-metallurgy of Sn.
	Gaugain	C. R., LXIX, 1300; Instit., 1869, 401; JB., 1867, 147; Quart. J. Sci., 1, V, 116; Phil. Mag., 4, XXXIV, 553; Chem. News, XVI, 156.	Polarization of electrodes.
	Hoffmann	Pogg., CXXXII, 607; Bull. Soc. Chim., X, 228.	Electrolysis of water.
	Lecoq	Bull. Soc. Chim., VII, 468.	Analysis of Cu and Ni.
	"	" " XI, 35.	Separation of Fe and Cu.
	Levison	Am. J. Min., 1867, June 15, July 20.	Electrolytic action of Na amalgam in the extraction of gold.
	Matteucci	C. R., Jan., 1867; Quart. J. Sci., 1, V, 116.	Polarization of electrodes.
	Paalzon	Berl. Monatsber., 1868, 490.	Electrolysis of salts.
	Planté	Chem. News, XVI, 243.	Lead electrodes.
	Renault	A. c. p., 4, XI, 137; JB., 1867, 115.	Electrolysis of gases.
	Salet	Laborat, 1867, 248; JB., 1867, 117.	Laws of electrolysis.
	?	Sci. Amer., 2, XVI, 214.	Electro-metallurgy.
	?	J. Fr. Inst., 3, LIV, 202.	Electro-metal. of bronze.
1868	Becquerel	C. R., LXVI, 77, 245, 766, 1066; Instit., 1868, 50, 131, 177; Arch. ph. nat. [N. P.], XXXIII, 31; Phil. Mag., 4, XXXVI, 437; JB., 1868, 82.	Electro-capillarity and electrolysis.
	"	C. R., LXVII, 1081; Instit., 1868, 386; Zeitsch. Chem., 1869, 134; JB., 1868, 87.	Silicates by electrolysis.
	Balsamo	Bull. Soc. Chim., IX, 250.	Electro-metallurgy of Fe.
	Bloxam	Chem. News, XIX, 289; JB., 1868, 151.	Electrolysis of nitre.
	Bourgoin	Bull. Soc. Chim., X, 206; D. C. Ges., II, 563; C. R., LXVII, 94.	Electrolysis of water.
	"	Bull. Soc. Chim., 2, XII, 438; X, 3, 209; IX, 427, 301, 431, 34; Quart. J. Sci., 1, VI, 266; J. Pharm., 4, XI, 10; D. C. Ges., 1869, 659; JB., 1869, 152; A. c. p., 4, XIV, 157, 430; Chem. News, XVI, 38.	Electrolysis of organic bodies.
	Corson	Sci. Amer., 2, XVIII, 363.	Separation of gold.
	Darling	J. Chem. Soc., XXI, 502.	Elect of alkaline acetates.
	Dumas	B. Soc. l'Ind., 2, XV, 383.	Electro-metallurgy.
	Farre	C. R., LXVI, 252, 470, 1231; LXVII, 1012; Pogg.,	Heat and electrolysis.

1868		CXXXV, 300; Phil. Mag., 4, XXXV, 289; XXXVIII 310; JB., 1868, 91.	
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	Gates	U. S. Pat. Rep., 1868, 80402.	Electro-plating.
	Jacobi	Bull. Soc. S. Peters., XII, 563.	Electro-metallurgy.
	Klein	B. Soc. l'Ind., 2, XV, 286; Chem. News, XVII, 133; Bull. Soc. Chim. 2, XI, 428.	Electro-deposition of Fe.
	Kness	Bull. Soc. Chim., 2, IX, 416; Sci. Amer., 2, XX, 184.	Electro-metallurgy.
	Kolbe	J. Chem. Soc., XXI, 195.	Electrol. of acetic acid.
	Lisenko	Zeitschr. Chem., 1868, 282; Jahresb., 1868, 91.	Electrolysis of gases.
	Raoult	C. R., LXIX, 823; JB., 1868, 49.	Electrolysis of salts.
	"	C. R., LXVI, 353; LXVI, 950, 1006; JB., 1868, 93.	Heat and electrolysis.
	Remington	U. S. Pat. Rep., 1868, 82877.	Electro-metallurgy of Ni.
	Rundspaden	Ann. Pharm., CLI, 306; JB., 1868, 150.	H_2O_2 by electrol. of H_2O.
	Tyndall	Am. J. Sci., 2, XLV, 34; XLVI, 180.	Faraday as a discoverer.
	Walenn	Chem. News, XVI, 170.	Electro-metallurgy of Fe.
	Warburg	Pogg., CXXXV, 114; JB., 1868, 93.	Electrolysis of $H_2 SO_4$.
	Wilde	Phil. Mag., 4, XXXVI, 81.	Laws of electrolysis.
	Weith	Bull. Soc. Chim., X, 121.	Electrol. of nitro-prussides.
	Wöhler	Ann. Pharm., CXLVI, 263, 375; JB., 1868, 192; Chem. News, XVIII, 189.	Oxidation by electrolysis.
	Woodworth	U. S. Pat. Rep., 1868, 84243.	Electro-plating.
	Wright	" " 1868, 79427.	The same.
	Zaliwski	C. R., LXVI, 1106.	Voltametric decomposition.
	?	Sci. Amer., 2, XVIII, 377.	Paper silvered.
	?	Pogg., CXXXV, 124.	Electrolysis by the spark.
	?	" " 293.	Electrolysis.
	?	" " 115.	Electrolysis at high temperatures.
	?	J. Fr. Inst., 3, LV, 368.	Electro-bronzing.
1869	Adams	U. S. Pat. Rep., 1869, 90332.	Electro-metallurgy of Ni.
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	Berthelot	J. Pharm., 4, II, 200; Bull. Soc. Chim., 2, XIII, 107; C. C., 1870, 226; JB., 1870, 159; Quart. J. Sci., VI, 320; Chem. News, XVIII, 82.	Electrolysis by the induction spark.
	Bourgoin	Bull. Soc. Chim., 2, XII, 400; JB., 1869, 152.	Electrol. of organic bodies.
	"	Bull. Soc. Chim. 2, XI, 39; XII, 433; D. C. Ges., II,	Electrolysis of soda, potash and ammonia.

		15; Chem. News, XIX, 213; A. c. p., 4, XV, 48.	
1869	Clay	Sci. Amer., 2, XXI, 346.	Electro-metallurgy of Fe.
	Delaurier	C. R., LXVIII, 1124.	Electro-metallurgy of Cu.
	Friedel	Quart. J. Sci., 1, VI, 471.	Electrolysis of H_4Si.
	Gerland	Pogg., CXXXVII, 552; Anz. Ann. Chim., 4, XVIII, 461; JB., 1869, 147.	Electrolysis of water.
	Gore	Quart. J. Sci., 1, VI, 319.	Electrolysis of HFl.
	Hoffmann	Deut. Ges. Ber., 1869, 244.	Laws of electrolysis.
	Jacobi	Bull. Soc. Chim., 2, XII, 498; Bull. Sci. S. Peters., XIII, 40.	Electro-metallurgy of Fe.
	Kolrausch	Pogg., CXXXVIII, 385.	Electrolysis of H_2SO_4.
	Maisstrasse	B. Soc. l'Ind., 2, XVI, 590; XVII, 103.	Electro-metallurgy of Zn.
	Patry	Arch. ph. nat. [N. P.], Nov., 1868; Phil. Mag., 4, XXXVII, 475.	Research on electrodes.
	Rust	U. S. Pat. Rep., 1869, 98110.	Electrolysis of alloys.
	Tait	Phil. Mag., 4, XXXVIII, 243.	Electrolytic polarization.
	Tucker	U. S. Pat. Rep., 1869, 90894.	Electro-gilding on iron.
	Ullgren	Bull. Soc. Chim., 2, XII, 249.	Analysis of Cu and Ni.
	Varrentrapp	Bull. Soc. Chim., 2, XII, 420; Schweiz Polyt. J., 1868, 87; Zeitsch. Chem., XI, 732.	Electro-metallurgy of Fe.
	Warburg	A. c. p., 4, XVI, 489; Pogg., CXXXV, 114.	Heat in electrolysis.
	?	Sci. Amer., 2, XXI, 153.	Electro-gilding.
	?	" " 2, XXI, 278.	Baths for electro-plating.
	?	J. Fr. Inst., 3, LVIII, 370.	Electro-metallurgy of Fe.
	?	Sci. Amer., 2, XXI, 91.	Electro-plating paper.
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	"	C. R., LXXI, 197; Instit., 1870, 225; JB., 1870, 149.	Laws of electro-capillarity.
	Bloomstrand	D. C. Ges., III, 533.	Classification of elements.
	Bourgoin	A. c. p., 4, XXI, 264; C. R., LXX, 811; JB., 1870, 274.	Electrolysis of acids.
	"	A. c. p., 4, XXI, 264; C. R., LXX, 191; J. Pharm., XII, 8; JB., 1870, 154; D. C. Ges., III, 325.	Electrolysis of salts.
	"	Bull. Soc. Chim., 2, XVII, 244; A. c. p., 4, XXVIII, 119; J. Chem. Soc., XXV, 27; JB., 1870, 108.	Theory of electrolysis.
	Boisfeillet	B. Soc. l'Ind., 2, XVII, 588.	Electrol. in photography.
	Bunge	D. C. Ges., III, 295, 911; Amer. Chem., I, 36, 310;	Electrolysis of salts.

		Bull. Soc. Chim., 2, XIV, 220; Chem. News, XXIII, 22; JB., 1870, 155.	
1870	Burckhard	Jen. Zeitschr., V, 393; Zeitschr. Chem., 1870, 212; Bull. Soc. Chim., 2, XIV, 35; JB., 1870, 157; Chem. News, XXI, 238; Amer. Chem., I, 37; Quart. J. Sci., 2., I, 430.	Electrolysis of salts.
	Christofle	Bull. Sci. S. Peters., XV, 319.	Electro-metallurgy.
	Gaiffe	Quart. J. Sci., 1, VII, 289.	Nickel plating.
	Hittorf	Pogg. CVI, 348; JB., 1870, 134.	Electrolysis of water.
	"	Pogg., CVI, 542; JB., 1870, 136.	Electrol. of Zn and Cd.
	Houzeau	C. R., LXX, 1286; Chem. News, XXI, 298; Amer. Chem., 1, 68; Quar. J. Sci. [N. S.], IX, 994.	Electrolysis of air.
	Howard	U. S. Pat. Rep., 1870, 100038.	Electro-metallurgy of Sb.
	Kohlrausch	A. c. p., April, 1870; Phil. Mag., 4, XL, 229.	Ohm's law in electrolysis.
	Martin	C. R., LXX, 611; Chem. News, XXI, 154.	Ozone by electrolysis.
	Royer	C. R., LXX, 731; JB., 1870, 633.	Electrol. of organic bodies.
	Runspaden	Quart. J. Sci., 1, VII, 138.	Electrolysis of water.
	Wernicke	Bull. Soc. Chim., 2, XV, 50; Pogg., CXLI, 109; J. pr, Chem., 2, II, 419; Am. J. Sci., 3, I, 298.	Electrolysis of salts.
	Wright	U. S. Pat. Rep., 1870, 101075.	Electro-plating.
1871	Adams	" " 1871, 113612; B. Soc. l'Ind., 2, XIX, 163, 253.	Electro-metallurgy of Ni.
	Bingham	U. S. Pat. Rep., 1871, 115926; Sci. Amer., 2, XXV, 42; Bull. Soc. Chim., 2, XVIII, 139.	Electro-metallurgy of Sn.
	Bourgoin	A. c. p., 4, XXII, 361; JB.; 1871, 631; Bull. Soc. Chim., 2, XV, 8; D. C. Ges., V, 327.	Electrol. of organic bodies.
	Brodie	Proc. Roy. Soc., XX, 472; Bull. Roy. Soc., XXI, 482; Phil. Trans., CLXII, 495.	Electrolysis of gases.
	Farre	C. R., LXXIII, 1463; Quart. J. Sci., 2, II, 276.	Conduction by electrolysis.
	Lenz	B. Soc. l'Ind., XVIII, 155.	Electro-metallurgy of Fe.
	Merrick	Chem. News, XXIV, 100, 172; JB., 1871, 933; Bull. Soc. Chim., 2, XVI, 262.	Analysis of Cu and Ni.

1871	Moore	D. C. Ges., IV, 519; Am. J. Sci., 3, III, 177.	Electrolysis of $C_2H_4O_2$.
	Parmlee	U. S. Pat. Rep., 1871, 114191.	Electro-metallurgy of Ni.
	Pratt	" " 1871, 113090.	Electro-metallurgy.
	Quincke	Pogg., CXLIV, 1, 161; J. Pharm., 1871, 132; Phil. Mag., 4, XLIII, 396, 518.	Electrolysis.
	Schönn	Chem. News, XXIII, 59; Pogg., 1870, Sup. V, 11.	Electrolysis.
	Scoutten	Quart. J. Sci., 2, I, 299.	Electrolysis of wines.
	Skey	Chem. News, XXIII.	Electrolysis of oxides.
	Soret	A. c. p., 4, XXII, 150.	Electrolysis of oxygen.
	Walenn	Chem. News, XXII, 1; Sci. Amer., 2, XXIV, 119.	Electro-metall. of brass.
1872	Aarland	Chem. News, XXIV, 313; J. pr. Chem., 2, XVIII, 171.	Electrol. of itaconic acid.
	Beardslie	U. S. Pat. Rep., 1872, 12988.	Electro-metallurgy of Ni.
	Becquerel	C. R., LXXV, 1729; JB., 1872, 112.	Electrolysis of amalgams.
	"	C. R., LXXIV, 1310; JB., 1872, 114.	Electro capillarity.
	"	C. R., Jan., 1872; Chem. News, XXV, 70.	Decomposition by the spark due to calorific effects.
	Blanc	C. R., LXXV, 537.	H_2O_2 by electrolysis of H_2SO_4.
	Boillot	C. R., LXXVI, 628, 869, 1132, 1712; J. Chem. Soc., XXVII, 713; Chem. News, XXVII, 256; Chem. Soc. Trans. [V. S.], XI, 724.	Action of the electric brush on CyH and air.
	Böttger	Quart. J. Sci., 2, II, 407.	Electro-metallurgy of Zn.
	Brown	D. C. Ges., V, 484.	Electrolysis of sugar.
	Carstanjen	Bull. Soc. Chim., 2, XVII, 221; Jour. pr. Chem., IV, 376.	Electrol. of itaconic acid.
	Fearn	Bull. Soc. Chim., 2, XVIII, 43; XIX, 41.	Electro-metall. of alloys.
	Gladstone	Proc. Roy. Soc., XX, 218; Phil. Mag., 4, XLIV, 73; Chem. News, XXV, 145; Arch. ph. nat. [N. P.], II, 45, 413; JB., 1872, 111.	Electrolysis.
	Heeren	Bull. Soc. Chim., 2, XVIII, 371; Dingl. J., CCIV, 487.	Electro-metallurgy.
	Keith	Quart. J. Sci., 2, II, 402.	Electro-metallurgy of Ni.
	Kempf	Chem. News, XXIV, 157; J. pr. Chem.. CLXXI, Nos. 11, 12.	Electrolysis of acetates.
	Lecoq	Bull. Soc. Chim., 2, XVII, 41; C. R., LXXIII, 1322.	Separation of Fe and Cu.
	Lobstein	Bull. Soc. Chim., 2, XVII, 480.	Electro-metallurgy.
	Mansfeld	Z. anal. Chem., 1872, 1; JB., 1872, 912.	Analysis of Cu, Ni, Co.

1872	Paterno	D. C. Ges., V, 642.	Electrolytic equivalents.
	Raoult	C. R., LXXV, 1103; JB., 1870, 111.	Electrolysis of Cd.
	Ruhmkorff	Quart. J. Sci., 2, II, 403.	Ozone by electrolysis.
	Tavernier	Bull. Soc. Chim., 2, XIX, 90.	Electro-metall. of alloys.
	Thenard	C. R., LXXV, 118.	Electrolysis of gases.
	Thompson	Chem. News, XXIV, 194.	Electrolysis of Al.
	Wright	" XXVI, 113; Amer. J. Sci., 3, IV, 29; Chem. Soc. Trans. [N. S.], X, 1072.	Ozone by electrolysis.
	?	Sci. Amer., 2, XXVI, 26.	Electro-metallurgy.
1873	Aarland	J. Chem. Soc., XXVI, 377; J. pr. Chem., 2, VI, 256; Chem. News. XXVII, 35; Bull. Soc. Chim., 2, XIX, 258.	Electrol. of itaconic acid.
	Becquerel	C. R., LXXVII, 84; JB., 1873, 123.	Electrolysis of water.
	"	JB., 1873, 120.	Electro-capillarity.
	"	C. R., LXXVII, 1130.	Electrolysis and chemical affinity.
	Brodie	J. Chem. Soc., XXVI, 744; Proc. Roy. Soc., XXI, 245; Phil. Mag., 4, XLVII, 309.	Electrolysis of CO.
	Chalevier	J. Chem. Soc., XXVI, 29; C. R., LXXV, 536.	Electrolysis by the electric brush.
	Divers	D. C. Ges., VI, 75.	Electrolysis of NH_4NO_3.
	Dumas	C. R., LXXVI, 519.	Electrolysis of CO_2.
	Gourdon	" LXXVI, 1250.	Electro-metallurgy of Zn.
	Gramme	Sci. Amer., 2, XXIII, 120.	Electrotyping.
	Helmholtz	Ber. Mon., 1873.	Conduction in electrolytes.
	Houzeau	C. R., LXXVI, 1203.	Electrolysis by the brush.
	Jean	" " 1203.	Action of the brush on CO_2.
	Kohlrausch	Pogg., CXLIX, 171; JB., 1873, 125.	Electrolysis of Ag.
	Ladenburgh	J. Chem. Soc., XXVI, 26; D. C. Ges., V, 753.	Electrolysis and molecular weight.
	Le Blanc	Chem. Soc. Trans., XXVI, 242.	H_2O_2 by electrol. of H_2SO_4.
	Levison	J. Fr. Inst., May, 1873.	Production of NH_3 in nitric acid batteries.
	Lippmann	Pogg., CXLIX, 547; Phil. Mag., 4, XLVII, 28.	Action of ions on electrodes.
	Maistrasse	B. Soc. l'Ind., 2, XX, 689.	Electrolysis of Sn.
	Maumené	C. R., LXXVI, 1146.	Electrolysis by the brush.
	Moncel	J. Chem. Soc., XXVI, 833; C. R., LXXVI, 1136.	Mercury electrodes.
	"	" LXXVI, 1015.	Electrolysis by the brush.
	Pisati	D. C. Ges., VI, 142.	Modifications of electrol.
	Raoult	C. R., LXXVI, 156; JB., 1873, 125.	Electrolysis of Zn, Cd, Sn.
	Sundell	Pogg., CXLIX, 144.	Electrolysis of metals.

1873	Thénard	C. R., LXXVI, 1082, 1508, 1048, 183, 517; J. Chem. Soc., XXVI, 1093; Chem. News, XXVII, 243.	Electrolysis by the electric brush.
	?	Sci. Amer., 2, XXIII, 23.	Electro-metallurgy.
	?	" 2, XXIX, 71.	Electro-plating with Sn.
	?	J. Chem. Soc., 1873, 452.	Electrolysis of Zn.
1874	Becquerel	C. R., LXXIV, 82; LXXVI, 245, 845; LXXVIII, 89, 1018, 1081; LXXIX, 82, 1281; JB., 1874, 132, 133.	Electro-capillarity.
	Bourgoin	D. C. Ges., VII, 1039.	Oxymalinic acid.
	Boillet	C. R., LXXIX, 636.	Electrolysis by the brush.
	Domanlip	J. Chem. Soc., XXVII, 645; C. C., 1873, 177.	Mechanical theory of electrolysis.
	Dumas	C. R., LXXVIII, 313.	Electrol. of acetic acid.
	Favre	" LXXVIII, 1678; JB., 1874, 130; D. C. Ges., VII, 950; J. Chem. Soc., XXVII, 861; Chem. News, XXX, 63.	" of carbonates of soda.
	Gladstone	Br. A. Ad. Sci., 1874, 56; Instit., 1874. 354; JB., 1874, 130; Chem. News, XXXI, 49.	Electrolysis of Cu and Pt.
	Martin	C. R., LXXVIII, 1354.	Analysis by electrolysis.
	Onimus	" LXXVIII, 643; JB., 1874, 131.	Electro-capillarity.
	Renard	C. R., LXXIX, 508, 159; JB., 1874, 128.	Passive iron.
	Regnon	C. R., LXXIX. 299; JB., 1874, 129.	The same.
	Schrötter	Pogg., CLII, 171; Phil. Mag., 4, XLVIII, 239.	Electrolysis of P.
	Slavik	D. C. Ges., VII, 1051.	Electrolysis of salts.
	Symons	J. Chem. Soc., XXVIII, 328; Pharm. J. Trans., 3, V, 325; Br. A. Ad. Sci., 1874, 31; JB., 1874, 131.	Electrolysis of oils and non-conductors.
	Thénard	C. R., LXXVIII, 219.	Electrol. of acetic acid.
	Thompson	Proc. Roy. Soc., 1874.	Electrolytic conduction in hot glass.
	Wittstein	Bull. Soc. Chim., 2, XXI, 565; Dingl. J., CCXII, 137.	Silver baths in electroplating.
	Wright	Am. J. Sci., 3, VI, 184; Chem. Soc. Trans. [N.S.], XII, 975.	Ozone by electrolysis.
	?	J. Fr. Inst., 3, LXVII, 12.	Iron electrotypes.
1875	Becquerel	C. R., LXXX, 411.	Electrolysis in nutrition.
	"	C. R., LXXX, 411, 585; JB., 1875, 102, 142.	Electro-capillarity.
	"	C. R., LXXXI, 1002.	Electrol. of organic bodies.
	"	" LXXXI, 803, 849.	Electrolysis and chemical affinity.

1875	Boillet	C. R., LXXX, 1167.	Ozone by electrolysis.
	Budde	Pogg., CLVI, 618; JB., 1875, 100; J. Chem. Soc., XXIX, 865.	Electrolysis.
	Christomanos	Gaz. Chim. Ital., 1875, 402; JB., 1875, 397.	Diphenyl by electrolysis.
	Coquillon	D. C. Ges., VIII, 1534.	Electrol. of aniline salts.
	Ducretes	C. R., LXXX, 280; JB., 1875, 100.	Aluminium electrodes.
	Fleming	Br. A. Ad. Sci., 1875, 28.	Electrolysis by the spark.
	Gladstone	Proc. Roy. Soc., XXIV, 47; JB., 1875, 101.	Electrolysis.
	Goppelsröder	C. R., LXXXI, 944; D. C. Ges., IX, 959; JB., 1875, 102.	Electrolysis of aromatic compounds.
	Janeczek	J. Chem. Soc., XXIX, 182; D. C. Ges., VIII, 1018; JB., 1875, 101.	Theory of electrolysis.
	Müller	J. Chem. Soc., XXVIII, 123; Pogg., CLI, 286.	Distribution of the current in the electrolyte.
	Obach	Pogg., VII, Sup., 280; JB., 1875, 97.	Electrol. of amalgams.
	Renard	D. C. Ges., VIII, 182; C. R., LXXX, 105, 236.	Electrolysis of alcohol.
	"	C. R., LXXXII 562; LXXXI, 188; Chem. News, XXXI 72; XXXII, 84.	Electrol. of glycerine.
	Tribe	Proc. Roy. Soc., XXIV, 308; J. Chem. Soc., XXX, 36; Chem. News, XXXIII, 213; JB., 1876, 126.	Theory of electrolysis.
1876	Becquerel	C. R., LXXXII, 1007.	Electro-capillarity.
	"	" LXXXII, 353.	Electrol. by the spark.
	Berthelot	" LXXXII, 1002.	Currents of high tension.
	"	" LXXXII, 1360.	Electrol. by the brush.
	Bertrand	" LXXXIII, 854; J. Chem. Soc., XXXI, 161; JB., 1876, 126.	Electrolysis of Al, Mg, Cd, Sb, Bi, and Pt.
	Bleekrode	Proc. Roy. Soc., XXV, 322.	Electrolysis.
	Bunge	D. C. Ges., 1876, 1598; JB., 1876, 128.	Electrol. of formic acid.
	"	D. C. Ges., IX, 78.	Electrol. of oxalic acid.
	Cazeneuve	J. Chem. Soc., XXX, 456; C. R., LXXXII, 1341.	Metallic films on organic substances by electrol.
	Christomanos	D. C. Ges., VIII, 1359.	Electrol. of acetylchloride.
	De la Rue	Proc. Roy. Soc., XXV, 323.	Electrolysis of HCl.
	Dossios	D. C. Ges., IX, 1792.	Theory of electrolysis.
	Elsässer	" " IX, 1818; Bull. Soc. Chim., 2, XXVIII, 469; J. Chem. Soc., XXXI, 676.	Mg and Pt electrodes.
	Fuchs	Pogg., CLIX, 486; JB., 1876, 126.	Electrolysis.
	Gladstone	J. Chem. Soc., 1876, 2, 152; JB., 1876, 127, 129; C. C., 1876, 545; Chem. News, XXXIII, 218; D. C. Ges.,	Electrolysis of water.

1876		IX, 950; Bull. Soc. Chim.. 2, XXVIII, 107.	
	Goppelsröder	D. C. Ges., IX, 59; C. R., LXXXII, 1199; Chem. News, XXXIV, 118; JB., 1876, 129.	Electrol. of aniline salts.
	Guillaume	C. R., LXXXII, 349.	Electrol. of liquid CO_2.
	H. H. B. S.	J. Chem. Soc., XXX, 115; C. C., 1875, 527.	Electrol. in assaying.
	Monrocy	Bull. Soc. Chem., 2, XXVI, 525.	Electro-metall. of Bi, Sb.
	Roberts	Chem. News, XXXI, 137.	Electrolysis of Fe.
	Schiel	Pogg., CLIX, 489; JB., 1876, 127.	Electrolysis of gold salts.
	Schiff	D. C. Ges., IX, 344.	Electrolysis of salts.
	Wöhler	" " IX, 1821.	H at both electrodes.
1877	Becquerel	C. R., LXXXIV, 145	Electrolysis in capillary tubes.
	Beetz	Ann. Phys., 2, II, 94; JB., 1877, 165; J. Chem. Soc., XXIV, 2; D. C. Ges., X, 118.	Electrolysis with Al. electrodes.
	Berthelot	A. c. p, 5, XIV, 361; C. R., LXXXVI, 71.	Electrolysis of water.
	Böttger	J. Chem. Soc., XXXII, 375; C. C., 1876, 640.	Electrolysis of Co.
	Bourgoin	Bull. Soc. Chim., 2, XXVII, 545; XXVIII, 51; C. R., LXXXIV, 1231.	Electrolysis of pyrotartaric acid.
	Fleming	J. Chem. Soc., XXXI, 266; Phil. Mag., 5, I, 142; Proc. Roy. Soc., XXVI, 40.	Polarization of electrodes.
	Frentz	J. Chem. Soc., XXXII, 239; C. C., 1876. 592.	Electrolysis of Pl.
	Gibbs	D. C. Ges., X, 1388.	Electrolysis of NH_4NO_3.
	Gladstone	Proc. Roy. Soc., XXVI, 2.	Conduction of organic bodies.
	Goppelsröder	Dingl. J., CCXXI, 81; CCXXIII, 317, 634; CCXXIV, 92, 209; JB., 1877, 166.	Electrol. of organic bodies.
	Guerout	C. R., LXXXV, 225; JB., 1877, 166.	Electrolysis of H_2SO_4.
	Hellesen	Chem. News, XXXV, 72; C. R., LXXXIV, 85.	Electrolysis of strong salts.
	Jablochkoff	" Dec., 1877.	Electrolysis of C.
	Javelle	" LXXXIV, 1171.	Electrolysis of naphthaline.
	Kohlrausch.	J. Chem. Soc., XXXI, 429; Dingl. J., CCXXII, 283.	Heat and electrolysis.
	Kowalewsky	Bull. Soc. Chim., 2, XXVII, 555; Ber., 1877, 413; JB., 1877, 166; D. C. Ges., X, 413.	Electrolysis of Cu SO_4.
	Parodi	J. Chem. Soc., XXXII, 804; Gaz. Chim. Ital., VII, 222.	Analysis of Zn and Pb.
	Planté	C. R., LXXXIV, 26.	Electrolysis of Si.

1877	Reboulaud	C. R., LXXIV, 1231; Bull. Soc. Chim., 2, XXVII, 545; JB., 1877, 166.	Electrol. of organic bodies.
	Rout	J. Chem. Soc., XXXII, 161, 271; C. C., 1876, 401.	Platinum penetrated by electrolytic gases.
	Thénard	J. Chem. Soc., XXXII, 269; C. R., LXXXIV, 706.	Electro-metallurgy.
	Thruchot	C. R., LXXXIV, 714.	Electrolysis by the spark.
	Tribe	Proc. Roy. Soc., XXVI, 222; JB., 1877, 165.	Electrolysis.
	Wrightson	J. Chem. Soc., XXXI, 340; Zeitsch. anal. Chem., 1876, 297.	Analysis by electrolysis.
1878	Becquerel	C. R., 1878, 1018, 1081.	Electro-capillarity.
	Berggren	J. Chem. Soc., XXXIV, 101; A. c. p., 5, I, 499.	Conductivity of electrolytes.
	Berthelot	J. Chem. Soc., XXXIV, 554; C. R., LXXXVI, 277.	Electrolysis of persulphuric acid.
	Bleekrode	Ann. Phys., 2, III, 161; Phil. Mag., 5, V, 375, 439; JB., 1878, 148; J. Chem. Soc., XXXIV, 464.	Electrol. of simple salts.
	Bouvet	C. R., LXXXVII, 1068; J. Chem. Soc., XXXVI, 293.	Electrol. under pressure.
	Coppola	Gaz. Chim. Ital., VIII, 60; Ann. Phys. Beibl., II, 353; JB., 1878, 152.	Electrolysis of glucose.
	Delcambre	Bull. Soc. Chim., 2, XXX, 431.	Electro-metallurgy.
	Ebermayer	J. Chem. Soc., XXXIV, 178; Dingl. J., CCXXIV, 631.	Electro-gilding.
	Elsässer	Ann. Phys. Beibl., II, 352.	H at both electrodes.
	Exner	Wien. Akad. Ber., 2, LXXVII, 655.	Electrolysis of waters.
	Gladstone	Chem. Soc. J., XXXIII, 139; Chem. News, XXXVII, 68.	Electrolysis.
	Herwig	J. Chem. Soc., XXXIV, 191; Ann. Phys., 2, IV, 173.	Movements of mercury in electrolysis.
	Hittorf	" 2, IV, 374; JB., 1878, 149.	Electrolysis of salts.
	Kayser	J. Chem. Soc., XXXIV, 537; C. C., 1878, 127.	Electro-metallurgy of Ni.
	Kirmis	Ann. Phys., 2, IV, 502; JB., 1878, 150.	Research on the ions.
	Leeds	Ann. N.Y. Acad. Sci., I, 197; Chem. News, XXXVIII, 224.	Ozone by electrolysis.
	Lippmann	J. Chem. Soc., XXXIV, 926; C. R., LXXXVI, 1540.	Electrodes in metallic solutions.
	Morges	C. R., LXXXVII, 15; C. C., 1878, 602; JB., 1878, 151.	Electrolysis of Cr.

1878	Pratt	Bull. Soc. Chim., 2, XXIX, 142.	Electro-metallurgy of Ag.
	Wright	J. Chem. Soc., XXXIV, 251; Am. J. Sci., 3, XIV, 167.	Specula coated by electrolysis.
1879	Berthelot	C. R., LXXXIX, 683.	Electrolysis of Au.
	Bode	J. Chem. Soc., XXXVI, 760; Dingl. J., CCXXXI, 254, 357, 428.	Electro-metallurgy.
	Braun	J. Chem. Soc., XXXVI, 194; Ann. Phys., 2, IV, 476.	Electrolytic conduction.
	Dewar	Proc. Roy. Soc., XXIX, 188.	Electrolysis of HCN.
	"	" " XXX, 170.	Electrolytic experiments.
	Levison	Am. J. Sci., 3, XIX, 29.	Electrolytic phenomena.
	Schöne	J. Chem. Soc., XXXVI, 878.	Electrolysis of H_2O_2.
	Troost	Quart. J. Sci., 3, I, 708.	Electro-metallurgy of Co.
1880	Bandet	C. R., XCI, 1004.	Ozone by electrolysis.
	Bourgoin	" XC, 608; Chem. News, XLI, 183.	Electrol. of malonic acid.
	Habermann	Wein. Acad. Ber., 3, LXXXI, 747; JB., 1880, 175.	Electrol. of organic bodies.
	Hautefeuille	C. R., XCI, 28.	Electrolysis by the slow discharge.
	Leeds	Lond. J. Sci., 3, II, 145.	Ozone by electrolysis.
	Ohl	Zeitschr. anal. Chem., XVIII, 521; Chem. News, XLI, 25.	Analysis of Co, Ni, and Cu by electrolysis.
	Renard	C. R., XC, 531; Chem. News, XLI, 172.	Electrol. of terebenthine.
	"	C. R., XCI, 175.	Electrolysis of benzine.
	Schucht	Chemikerzeitung, 1880, 292; Zeitung, XXXIX, 121; JB., 1880, 174; Chem. News, XLI, 280.	Electrol. of U, Th, V, Pl.
	Smith	JB., 1880, 174; D. C. Ges., 1880, 751.	Electrolysis of iron.
	Weston	Ann. Phys. Beibl., IV, 70; JB., 1880, 177.	Electro-metallurgy of Ni.

LIST OF ABBREVIATIONS.

A. c. p.	Annales de chimie et de physique,—Paris.
Am. Chem.	American Chemist,—New York.
Am. J. Min.	American Journal of Mining,—New York.
Am. J. Sci.	American Journal of Science and Arts, Silliman and Dana,—New Haven, Conn.
Ann. Elect.	Annals of Electricity,—London.
Ann. Ch. Pharm.	Annalen der Chemie und Pharmacie,—Heidelberg.
Ann. d. M.	Annales des mines,—Paris.
Ann. N. Y. Acad. Sci.	Annals of the New York Academy of Sciences,—New York.
Ann. Phys. Beibl.	Beiblätter zu den Annalen der Physik und Chemie.
Arch. Élect.	Archives de l'electricité,—Genève.
Arch. ph. nat.	Archives des sciences physique et naturelles,—Genève.
Arch. Pharm.	Archiv der Pharmacie,—Lemgo.
Arch. Neer Sci.	Archives Néerlandaises des sciences exactes et naturelles,—Haarlem.
Berl. Acad. Ber.	Bericht über die Verhandlungen der K. Preussiche Academie der Wissenchaften zu Berlin.
Berl. Monb.	Berlin. Monatsbericht.
Berz. Jahresb.	Jahresbericht über die Fortschritte der Chemie,—Berzelius, Tübingen.
Bibl. Univers.	Bibliothèque universelle des sciences,—Genève.
Br. A. Ad. Sci.	Report of the British Association for the Advancement of Science.
Basel, Ber.	Bericht über die Verhandlungen der naturforschende Gesellschaft zu Basel.
Br. d'Inv.	Descriptions des machines et procédes specifiés dans les brevets d'inventions,—Paris.
Br. Pat. Rep.	British Patent Reports.
Bull. Acad. Brus.	Bulletin de l'Académie royale,—Bruxelles.
Bull. de St. Pétersb.	Bulletin de classe physico-mathématique,—St. Pétersbourg.
Bull. Sci. St. Pétersb.	Bulletin Scientifique publié par l'Académie Imp. des Sciences,—St. Pétersbourg.
Bull. Soc. Chim.	Bulletin de la Société chimique de Paris.
B. Soc. l'Ind.	Bulletin de la Société d'encouragement pour l'industrie nationalc,—Paris.
C. C.	Chemisches Centralblatt,—Leipzig.
Chem. Gaz.	Chemical Gazette, Francis and Croft,—London.
Chem. News.	Chemical News, Crookes,—London.
Chem. Soc. Q. J.	Quarterly Journal of the Chemical Society,—London.
Chem. Soc. Trans.	Transactions of the Chemical Society,—London.
Chem. Soc. Mem.	Memoirs of the Chemical Society—London.
Cimento.	Il Cimento, giornale di fisica, ecc.,—Pisa.
Cosmos	Cosmos, les Mondes, Moigno, Paris.

C. R.	Comptes rendues des séances de l'Académie des sciences,—Paris.
Dingl. J.	Polytechnisches Journal, Dingler—Stuttgart.
D. C. Ges. or Deut. Ges. Ber.	Berichte der deutschen chemischen Gesellschaft zu Berlin.
Edinb. J. Sci.	Edinburgh Journal of Science,—Brewster.
Edinb. N. Phil. J.	Edinburgh New Philosophical Journal.
Edinb. Phil. J.	Edinburgh Philosophical Journal.
Elec. Mag.	Electrical Magazine,—London.
Eng. Arch. J.	Engineers' and Architects' Journal,—London.
F. R.	Faraday's Researches. Taylor,—London, 1844.
Gaz. Chim. Ital.	Gazzeta chimica Italiana,—Palermo.
Gaz. de L.	Gazette de Lausanne.
Gehlen's J.	Allgemeines Journal der Chemie, Gehlen,—Berlin.
Gel. Anz.	Gelehrte Anzeigen,—München.
Gilb. Ann.	Annalen der Physik. Gilbert,—Halle.
Göttl. Alm.	Göttling's Almanach für Scheidekünstler,—Weimar.
G. Sci. Mis.	Griffin's Scientific Miscellany,—Glasgow.
Hist. l'Acad.	Histoire de l'Académie des Sciences,—Paris.
Instit.	L'Institut.,—Paris.
Inv. Ad.	Inventor's Advocate,—London.
JB. or Jahresb.	Jahresbericht über die Fortschritte der Chemie, Giessen.
Jen. Zeitschr.	Jenaische Zeitschrift für Medicin und Naturwissenschaft,—Leipzig.
J. Fr. Inst.	Journal of the Franklin Institute—Philadelphia.
J. pr. C.	Journal für praktische Chemie, Erdmann, Leipzig.
J. Chem. Soc.	Journal of the Chemical Society,—London.
J. Roy. Inst.	Journal of the Royal Institution of Great Britain.
Journ. de Phys.	Journal de physique, Rozier,—Paris.
J. Pharm.	Journal de pharmacie et de chimie,—Paris.
J. Polyt.	Journal de l'École polytechnique,—Paris.
Kastn. Archiv.	Archiv. für die gesammte Naturlehre, Kastner,—Nürnberg.
Laborat.	Labsratory,—London.
Liebig's Ann.	Annalen der Chemie und Pharmacie—Liebig.
Lond. J.	London Journal of Arts and Sciences,—Newton.
Mech. Mag.	Mechanics' Magazine,—London.
Mém. de l'Acad. Sci.	Mémoires de l'Académie des sciences,—Paris.
Mém. Soc. Imp. M.	Mémoires de la Société impériale des naturalistes,—Moscow.
Mem. Acad. T.	Memoirs of the Royal Academy of Sciences, Turin.
Neues Jour.	Neues Journal für Chemie und Physik, Schweigger-Seidel, Nürnberg.
N. Ed. Phil. J.	Edinburgh New Philosophical Journal, Jameson.
Nich. J.	Journal of Natural Philosophy, Chemistry and the Arts, Nicholson,—London.
N. Gehl.	Journal für Chemie und Physik, Gehlen, Leipzig.
N. Pét. Acad. Bull.	Bulletin de l'Académie des sciences de St. Pétersbourg.
Nov. Com. Bon.	Novi commentarii academiae scientiarum instituti Bonoviensis,—Bologna.
Pat. J.	Patent Journal,—London.
Pharm. Cent.	Pharmaceutisches Centralblatt,—Leipzig.

Pharm. J.	Pharmaceutical Journal and Transactions,—London.
Phil. Mag.	London, Edinburgh and Dublin Philosophical Magazine,—London.
Phil. Trans.	Philosophical Transactions of the Royal Society,—London.
Pogg.	Annalen der Physik und Chemie, Poggendorf,—Berlin.
Proc. Roy. Soc.	Proceedings of the Royal Society of London.
Quart. J. Sci.	Quarterly Journal of Science, Crookes,—London.
Rec. Pat. Inv.	Record of Patent Inventions,—London.
Rep. of Arts.	Repertory of Arts and Manufactures—London.
Rep. Br. Assoc.	Reports of the British Association for the Advancement of Science.
Rép. Chim. app.	Répertoire de chimie appliquée,—Paris.
Rép. Chim. pure.	Répertoire de chimie pure,—Paris.
Rev. Sci.	Revue des sciences—Paris.
Roma, Atti.	Atti dell' accademia Pontificia dei nuovi Lincei,—Roma.
Schweigg.	Journal für Chemie und Physik, Schweigger, Nürnberg.
Schweiz. polyt. Z.	Schweizerische polytechnische Zeitschrift,—Winterthur.
Sci. Amer.	Scientific American, New York.
T. Ann.	Thompson's Annals,—London.
U. S. Pat. Rep.	United States Patent Reports.
Wien Akad. Ber.	Sitzungsberichte der naturwissenschaftliche Classe der Kaiserlich. Akademie der Wissenschaften zu Wien.
Zeitsch. Chem.	Zeitschrift für Chemie,—Göttingen.
Zeitschr. Chem. Pharm.	Zeitschrift für Chemie und Pharmacie,—Erlangen.
Zeitschr. anal. Chem.	Zeitschrift für analytische Chemie, Fresenius,—Wiesbaden.

XX.—*Note relating to a Newly-Discovered Absolute Limit to Economical Expansion in Steam-Engines.*

BY ROBERT H. THURSTON.

Read October 2d, 1882.

NOTE.—This paper was prepared in the latter part of April, 1882, and sent to the Academy for presentation. But an accidental non-delivery prevented its reaching the Committee on Papers and Publication, until too late for reading before the meetings were suspended for the summer. It was, therefore, presented at the first meeting of the autumn ; but its actual date of reading is really several months later than it should properly have been.

D. S. M.

A paper "On the Behavior of Steam in the Steam Engine, and on Curves of Efficiency,"* was read by the writer before the New York Academy of Sciences, February 13th, 1882.

In that paper it was shown that, if a "Curve of Efficiency" were constructed for any steam engine, such that its ordinates should be proportional to the work done by quantities of steam laid down in arithmetical progression as abscissas,—the quantity used at full stroke, *i. e.*, without expansion, being taken as unity,—that such curve would depart from the curve given by the ideal perfect engine, in character, form and location, and that it could not pass through the origin, as does that of the ideal engine, unless by passing through a point of inflection.

It was shown that, such a curve being constructed, ratios of expansion at maximum efficiency could be determined by drawing tangents to the curve from the junction of the back-pressure line with the ordinate passing through the origin. It was shown that the ratio so determined is larger as the ratio of initial to back-pressure increases. It is the object of this note to call attention to the fact that, for the real engine, there exists an absolute limit to economical expansion for every such engine, which cannot be exceeded, however high the pressure of steam may be carried.

* Trans. N. Y. Acad. Sci., February, 1882; Journal Franklin Institute, Feb., 1882.

For: when the steam-pressure (p^1) becomes infinite, the ratio ($r = \frac{p^b}{p^1}$) becomes zero, and the tangents to the curve of efficiency are drawn from the origin (*O, Fig.* 1).

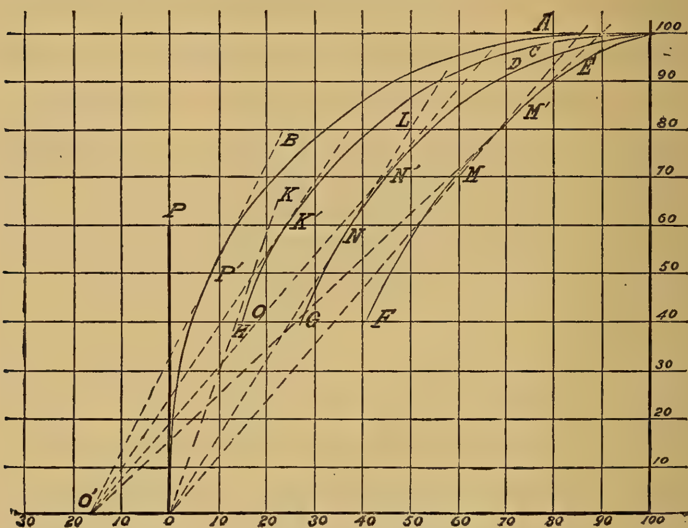

FIG. 1, CURVES OF EFFICIENCY.

The point of tangency, which, for the ideal case, *A B O* is found at the origin *O*, where $r = \infty$, is for the real case, *C D H* found at *H*, a point corresponding to some finite value of r. This point thus constitutes a limit to economical expansion such as is here considered, and which is now, so far as the writer is aware, first discovered.

It was shown, in a paper read before the Society of Mechanical Engineers, April, 1882,* that, by making the distance *O O'*, measured toward the left from the origin, proportional to the costs of engine, apart from the costs of supplying steam, and drawing tangents from *O'*, ratios of expansion at maximum commercial efficiency could be determined. It is now seen that such a limit as is above described is found not only for the real but also for the ideal engine, when commercial efficiency is studied, their limit being determined by the points of tangency *B* or *H*, given by the lines *O' B, O' K'*.

---

* Trans. Am. Soc. Mech. Engrs., 1882; Jour. Franklin Inst., May, June and September, 1882.

It is not only the fact that such limits exist, as here shown; but it is also the fact that the limit to economical expansion is reached at a low value of the ratio of expansion for ordinary engines—sometimes probably as low as 3 or 4.

Thus, in the condensing unjacketed engine of moderate speed, as in the United States steamer "Michigan," it will be found that, whatever steam-pressure is attained, there exists a limit to economical expansion at some point near $r=3$, and it can never, in such a case, be economical to "cut-off" within one-third stroke unless a better curve of efficiency is obtained.

In well-designed engines of more economical types, the limit is found at higher values of r, but may still occur within the range of expansion often met with in practice.

HOBOKEN, N. J., APRIL, 1882.

XX.—*Description of a New Species of Bird of the Family Cypselidæ.*

BY GEORGE N. LAWRENCE.

Read October 2d, 1882.

Hemiprocne minor.

Above, the plumage is of a lustrous black; the upper tail-coverts and tail are smoky blackish-brown; the wings are black; the quills, with the exception of the outer three, are narrowly margined with grayish-white at their ends; the chin and throat are fuliginous-brown; the breast, abdomen and under tail-coverts are smoky brownish-black; a white collar encircles the neck, behind it is rather narrow and well-defined, in front it is not so clearly defined, and widens out on the breast, where the feathers have their centres mottled with black; the collar on the hind neck is one-quarter of an inch in width; on the breast, at the widest part, it is three-quarters of an inch; bill black.

Length (skin), 7 inches; wing, 7; middle tail-feathers, 2⅛; outer tail-feathers, 2⅝.

Habitat, New Grenada, Bogota. Type in my collection.

Remarks.—This species differs from all its allies in its much smaller dimensions, and in the character of the collar in front.

The regular gradation in size of the four species of this genus is remarkable—the difference in total length and in that of the wing, between each, being approximately one inch.

H. semicollaris is in length	10	inches ;	the wing,	10.
H. zonaris,	"	9	"	"	9.
H. biscutata,	"	8.1	"	"	8.3.
H. minor,	"	7	"	"	7.

The localities of the several species are as given below :—

H. semicollaris seems to be strictly confined to Mexico, and is very rare in collections.

H. zonaris is the most widely distributed species, being noted from Brazil and the Argentine Republic ; I have specimens, also, from Jamaica and from Guatemala.

H. biscutata, I think, has been found only in south-eastern Brazil ; I obtained my specimen of it from a collection sent from Rio Janeiro.

H. minor, so far as known, inhabits only New Grenada.

VOL. II.

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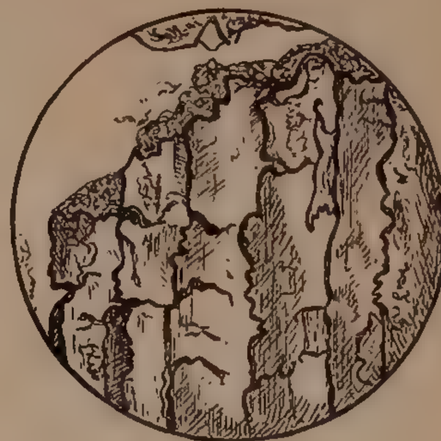

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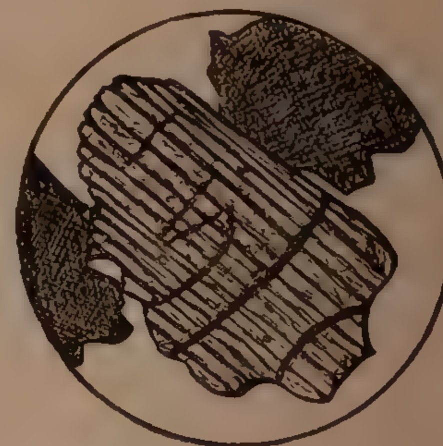

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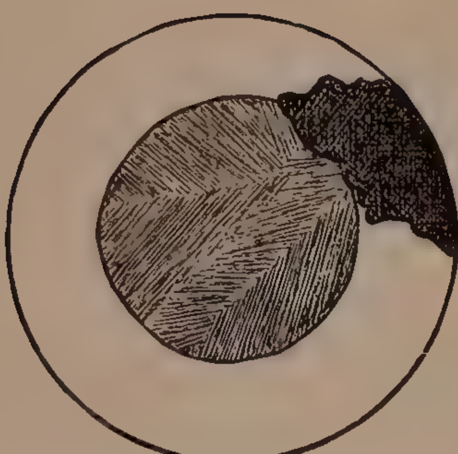

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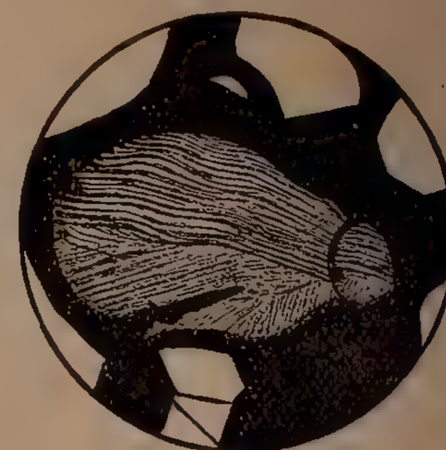

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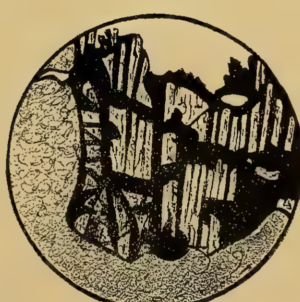

ANNALS

OF THE

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VOLUME II, 1880—82.

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XXI.—*The Origin of the Carbonaceous Matter in Bituminous Shales.*

BY JOHN S. NEWBERRY.

Read April 2d, 1883.

Among the sedimentary rocks, there are none in regard to the origin and mode of formation of which there has been more difference of opinion than the bituminous shales. These are typified by the Utica shale of the Lower Silurian, by the Hamilton shales of the Upper Devonian,—including the Marcellus, the Hamilton, the Genesee and Gardeau shales of the New York geologists, and their general equivalent, the Huron shale of Ohio,—by the Cleveland shale of the Lower Carboniferous, and by the bituminous shales, with their varieties, blackband iron ore and cannel coal, of the Coal Measures.

We also find in Colorado a great mass of bituminous shale occupying the central portion of the Cretaceous series, a part of the "Colorado Group."

These bituminous shales usually contain from ten to twenty per cent. of carbonaceous matter, the remainder being clay and very fine sand, with occasional specks of mica. As a general rule, such shales are not very fossiliferous, but the scales of small ganoid fishes and the singular denticles called Conodonts are almost always present, and not unfrequently we find minute flattened, originally spheroidal bodies, which are apparently the spores of plants. In the Utica shale, graptolites are exceedingly abundant, sometimes quite filling the rock; and trilobites, sponges and crustacea are sparingly found.

In the Devonian shales, the most common fossils are Lingulas, Discinas, a small Orthoceras, and bivalves of the genera Avicula and Lunulicardium; sometimes, also, a Pteropod (*Tentaculites fissurella*) in countless numbers; all these are minute. In the Huron shale, and recently, also, in the Devonian shales of New York, have been found the remains of large placoderm fishes in considerable numbers; but vast masses of this rock

may be examined with the discovery of no other fossils than seaweeds, which in some places quite cover the surfaces of the layers.

Economically, these shales are of great importance. In places they attain a thickness of several hundred feet, have a wide geographical range, and with their percentage of carbon form a store of combustible material, and a reservoir of power, far exceeding in quantity all the coal beds of the Carboniferous system; they are also undoubtedly the source from which the great flows of petroleum and carburetted hydrogen gas emanate at the West.

As we study the lateral extension and geological association of these bituminous strata, we find evidence that they have been deposited in comparatively shallow and narrow seas, not far distant from the shores.

Many suggestions have been made in regard to the origin of the vast accumulation of carbonaceous matter contained in these shales.

In a paper on the Rock Oils of Ohio, published in the Report of the State Board of Agriculture for 1859, I attributed the production of petroleum to the spontaneous distillation of the organic matter present in these beds, and ascribed the accumulation of this carbonaceous matter, for the most part, to sea-weeds, but crediting animal tissues with a portion of the product. Later, Mr. Lesquereux took the same view of the origin of petroleum, and I think this is now endorsed by the members of the Geological Corps of Pennsylvania who have given the phenomena of the production of petroleum the most careful and prolonged attention.

At the meeting of the American Association for the Advancement of Science, held at Montreal in August last, a communication was made to the geological section by Prof. Edward Orton, of Columbus, Ohio, in which, after citing many cases where spheroidal flattened organic granules were found in the Huron shale of Ohio,—bodies which he regarded as the spores of sea-weeds, or lycopods,—he attributed the carbonaceous matter which the shales contained chiefly to *them*. The paper of Prof. Orton was subsequently published in the American Journal of Science for September, 1882.

My object in now calling attention to this subject, is to point out some difficulties in the way of the acceptance of this theory, and to offer additional considerations in favor of the view previously proposed, that the carbonaceous matter is mainly derived from algæ.

It is true that in a great number of localities these minute spheroidal bodies occur, but they are not always or even generally present, and strata many feet in thickness and miles in extent may be examined without discovering any of them. They now form but a very insignificant fraction of the carbonaceous matter of the shales; and there seem to be good reasons for believing that they have always done so.

In the first place, they are apparently the organs of fructification of plants, but these in quantity always bear an altogether subordinate position to the vegetative tissues with which they are connected; and if it were true that the carbonaceous matter of these shales was derived only from the reproductive organs, we must account for the disappearance of the hundred times as much organic matter which once composed the organs of vegetation.

Second, it is one of nature's wise provisions that the envelops of the embryo in plants should be specially resistant to decay, as well as to the action of many destructive agents. The testa of some stone-fruits is the hardest plant-tissue known, and is specially adapted to resist mechanical violence. Many of the smaller drupes are eaten by birds and other animals, which have the power to digest the sarcocarp but leave the stone uninjured. So the spores are somehow much more enduring than other tissues of the plants that bear them, and are sure to be preserved out of all proportion to their quantity. Hence we may conclude that the spores of lycopods wafted from the land, or the spores of algæ which sunk here and there with the other materials of the shale, would be preserved, while at least all the cellular tissue of the plants would be disintegrated, though perhaps not destroyed.

Third, the great number of sea-weeds found fossilized in the shale indicates the abundance of this class of vegetation and possible source of carbonaceous matter. But the tissue of seaweeds is all cellular, is easily disintegrated, and has broken

down in almost all cases where these plants are found. If the carbonaceous matter of these shales is due to sea-weeds, it is not surprising that it is so generally decomposed.

Fourth, in addition to the larger forms of sea-weeds, there are many which are microscopic and uni-cellular; even out in the open ocean they occur in such numbers as to color the water for hundreds of square miles. Some of these, called *Zoözanthellæ* by Brandt, are so associated with the radiolarians as to form self-supporting communities; that is, the algæ draw their support from the sea-water, the animals subsisting on the algæ. Such organisms exist in overwhelming numbers in both fresh and salt water, and must be leaving an important residuum in diffused carbonaceous particles below their places of abode; we may well believe, therefore, that they have contributed to the formation of such bituminous strata as we are considering. That some part of this carbon may have been derived from the fatty portions of animals, is certainly possible; but their nitrogenized tissues decay with such rapidity, and these constitute so large a portion of most animal structures, that we must attribute the greater part of this organic matter to the preservation of the more abundant, more carbonaceous and more enduring tissues of plants.

In nearly all fresh water, and many marine basins, the microscopic protophytes, diatoms and desmids, swarm in countless numbers; the abundance of the diatoms being attested by the extensive beds of Tripoli (diatomaceous earth), many feet in thickness and many miles in extent, which are formed of the silicious frustules that have resisted decay. But the desmids and the carbonaceous portions of the diatoms have disappeared as such, yet we have reason to believe that they contributed their carbonaceous particles to the sediments which accumulated in the basins they inhabited.

In studying the area occupied by the bituminous shales which have been enumerated, we find they were deposited in shallow and shallowing seas,—the Utica shale in the retreat of the Lower Silurian sea, the Hamilton shales in the narrowed and shallowed basin where the Devonian limestones had been laid down. The Cleveland shale lies on the Waverley shales, the off-shore deposits of the Carboniferous sea, where the water was

not pure enough and deep enough to produce limestone. So too, the bituminous shales of the Colorado group were deposited near the shore of the Cretaceous sea. In Texas, where the Cretaceous series is nearly all marine limestones, we find no bituminous shales; but as we go west toward the Wasatch Mountains, the permanent shore of the Cretaceous sea, over very extensive areas these limestones are replaced by black shales, off-shore deposits, which are overlain by the Laramie group, shore and terrestrial accumulations, sandstone and conglomerate with coal strata—that is, old peat beds.

The upper Klamath Lake, in Oregon, is a body of water of considerable size, but so shallow that water-plants, particularly a yellow water-lily (*Nuphar polysepala*) root on the bottom, and cover a large part of the surface with their leaves. The decay of these succulent plants, existing in such quantity, must form a carbonaceous pulpy mass at the bottom. Since however, the lake is only an expansion of a river course,—as Klamath River enters at one end and leaves it at the other,—it is evident that at times the flow of this stream will bring in a considerable quantity of transported sediment to mingle with the carbonaceous residue; and it requires no prophet to foretell, that when the bottom of upper Klamath Lake shall be exposed to view, it will be found to be composed of materials which, if consolidated, would become bituminous shale.

That sheets of marine vegetation may sometimes cover large water surfaces, is shown in the existence of what are known as Sargasso seas. In the wider portions of the North Atlantic is that through which Columbus plowed his way, greatly to the alarm of his sailors; and others are known to exist in other portions of the great oceanic basins. Here the sea-weeds in the "Horse latitudes" are undisturbed by any storm, and grow disconnected with the earth, forming sometimes a matted sheet of vegetation that conceals the water. With this growth must be decay, and we are compelled to imagine the accumulation beneath these sheets of sea-weed of a carbonaceous mud formed from the decomposing cellular tissue of the plants, and such inorganic matter as may be contained in their tissues, or is supplied by the decay of the animal organisms which inhabit such regions.

These very different examples of the operation of causes now in action would give us strata similar to those we have been studying; but we look in vain over the earth's surface for any illustration or confirmation of the theory which attributes the great stores of carbonaceous matter contained in them to the spores or pollen of plants.

Because the enduring sporangia of lycopods have remained in considerable numbers in the carbonaceous mass derived from the trees which bore them, and as sometimes these sporangia are the only definite forms visible to the eye, the theory has been proposed that to them chiefly we owe the accumulation of carbonaceous matter that we call coal; but the difficulty has been already suggested that these spores must have been associated with a thousand times more plant-tissue; and as they nowhere form more than a thousandth part of the mass, we cannot credit them with being the sources of the combustible. The probable cause of their abundance is, that they alone have preserved their forms, while other tissues have been disintegrated. The perfect preservation of the sporangia in the cones of fossil Lycopods,—Lepidostrobus, Flemingites, etc.,—show how resistant to decay they are.

It should also be said, that in some cases the spores of plants may have accumulated in local masses, like the masses of seeds and nuts in the lignites of Brandon, Vermont, and of Saltzhausen in Germany.

The annual dissemination of pollen in the cypress swamps affords no good arguments in behalf of this theory; for though for a brief moment of the year somewhat abundant, scattered widely by the winds, and conspicuous for its color, it has attracted attention, no one will claim that any considerable portion of the accumulations of carbonaceous matter which are now taking place in or around the cypress swamps is derived from this source.

The composition of bituminous shales may be inferred from the following analyses, made from specimens taken from several geological horizons:—

	1	2	3	4	5	6
Moisture,	1.10	0.86	0.75	0.54	——	1.10
Inorganic matter,	87.10	84.60	78.29	83.17	79.36	76.00
Volatile combustible do.	6.90	8.36	14.12	8.26	12.60	11.30
Fixed Carbon,	4.90	6.18	6.84	8.03	8.04	11.60
	100.00	100.00	100.00	100.00	100.00	100.00

No 1. Cleveland Shale, Carboniferous, Cleveland, Ohio, (Wormley.)
No. 2. Huron Shale, Monroeville, Ohio, - - - (Wormley.)
No. 3. Hudson River Shale, Savannah, Ills., - - (Chandler.)
No. 4. Utica Shale, Dubuque, Iowa, - - - (Chandler.)
No. 5. " " Collingwood, Canada, - - (Hunt.)
No. 6. Genesee Shale, Bozanquet, " - - - (Hunt.)

The relations of the bituminous shales to the cannel coals are very intimate; indeed they may be said to be but different phases of the same substance, as they have been formed in similar conditions, and shade into each other by insensible gradations. I have suggested a theory to explain the origin of cannel coal, which supposes it to be composed of the completely macerated parenchymatous tissue of plants, accumulated in lagoons or water-basins in the coal-marshes. The water of such lagoons in our present peat-bogs, and of streams flowing from them, is coffee-brown in color, from the carbonaceous particles disseminated through it. These, subsiding in basins of quiet water, form a carbonaceous mud which, when dried, is not unlike cannel coal. Where transported by streams, and mingled with a preponderance of earthy matter, the equivalent of bituminous shales is produced. In the Carboniferous age, like causes produced like effects; and cannel coal is found holding such relations to cubical coal (ancient peat) and to bituminous shales, that we can plainly read their closely connected histories.

In attributing the carbonaceous matter of cannels to macerated cellular plant-tissue, I would not be understood to exclude the microscopic algæ and protophytes (desmids and diatoms) from

all participation in the process of their formation; and we must concede not only the possibility but the probability that the streams, lakes, and shallow bays, where the cannel and bituminous shales accumulated—in former times as now—were crowded with the microscopic forms of plant-life, which left a residuum with the disintegrated tissue of the larger plants.

The cannels as a whole differ from cubical coals not only in physical structure,—lacking the lamination and pitchy brilliancy, as well as containing more ash,—but in chemical composition, since they yield a larger amount of volatile matter—gases and oils—and gases which have higher illuminating power. This, which is true of all cannels, is conspicuously so of the Torbane Hill cannel of England and the "Hartley mineral," "Wollongongite," from Australia. For example, the best cubical caking coals, such as are generally employed for the manufacture of gas, like the Pittsburgh or Westmoreland coals (and which are preferred, as they yield a fair volume of good gas and leave an excellent coke), furnish about 10,000 cubic feet of gas to the ton, while the cannels yield as much as 12,000 cubic feet, and the Wollongongite 15,000. These differences are doubtless in part due to the kind of vegetation from which the carbonaceous material was derived; the parenchymatous tissue probably furnishing more volatile matter than the ligneous, and the algæ perhaps more than the plants higher in the botanical scale. We can imagine, also, that certain plant-tissues which have contributed to the formation of such deposits as the Australian shale, may have been impregnated with hydro-carbons elaborated by vital processes, such as the resins. These must, however, be extreme and rare cases, and the differences between various coals and carbonaceous shales are probably differences of degree rather than of kind.

The spontaneous emission of carburetted hydrogen and petroleum from bituminous shales is so general that hundreds of localities might be cited where it may be observed; indeed a belt of oil-wells and gas-springs marks the line of outcrop of each of these beds of bituminous shale of whatever geological age. The organic portion of the shales, like all other organic matter, being in a state of unstable equilibrium, is constantly decomposing, either by direct and complete oxidation, or by a sort of

distillation through which the end is reached in a series of more or less distinct steps; that is, a fractional distillation results in the formation of evolved products, liquid or gaseous, which are slowly but constantly generated, and are, for the most part, immediately liberated, rising to the surface by hydrostatic pressure. Usually we find in the shales only the material out of which the volatile hydrocarbons *can be manufactured;* and as these are rapidly dissipated when formed, hand specimens and even larger exposed masses rarely show them; but in a great number of localities petroleum is found saturating the shale, betraying its presence by its characteristic odor when the rock is freshly broken; and it is sometimes present in such quantity as to form an oily film when fragments are thrown into water. Porous and shattered rocks which overlie the black shales are often the reservoirs which receive the evolved products of their spontaneous distillation; and here we find all the great stores of petroleum which supply the extensive commercial and industrial operations based upon it. I have elsewhere discussed the genesis of petroleum and carburetted hydrogen from these shales, and it is not necessary to treat the subject at length here. The hydrocarbons which have become so important in the economy of civilization, have been attributed by some to the action of inorganic causes. By others, who agree with me in ascribing them to an organic source, they have been regarded as emanations from other rocks than the bituminous shales; but no examples of the occurrence of these hydrocarbons in nature, except in connection with organic substances, are known; and as a matter of fact, no considerable accumulation of petroleum has been discovered except in close relationship with this group of carbon-bearing rocks. They are the great repositories of the materials from which the gaseous and volatile hydrocarbons can be produced, and we may say the only ones. They claim our interest, therefore, as the apparent source of the liquid and gaseous hydrocarbons which are of economic importance; and we must not only credit them with all the benefits conferred upon society by the excellent illuminator now furnished to every family at so low a price, but we must look to them as the source of supply of this necessity, as we may call it, when in the not distant future the stores produced by nature's processes

shall have been exhausted, and we are compelled to manufacture petroleum for ourselves, using nature's material, but substituting our quick for her slow methods.

Either the minute division of the carbonaceous matter contained in bituminous shales, and its distribution through a preponderating mass of inorganic material, or some inherent peculiarity of the plant-tissue which has furnished it, makes it more prone to spontaneous distillation than the pure and compacted hydrocarbons which form coal; for the evolution of the gaseous and liquid hydrocarbons from the shales is more conspicuous than from beds of coal, though noticeable in both; and the shales, though quite black when freshly broken, soon become brown by exposure even in the cabinet. Where subjected to the combined action of sun, air and moisture, they rapidly lose the carbon at the surface, and ultimately show only the ashen-grey color of their inorganic constituents.

The occurrence of iron pyrites in bituminous shales may be regarded as one of their characteristic features, and nothing is more common than to find the rock along certain lines thickly set with small, often spheroidal, and sometimes beautifully crystalized, concretions of pyrite. It is also the material by which organisms of various kinds, shells, bones, wood and the tissue of sea-weeds, are often replaced. The origin of the pyrites is probably due to sulphates,—sulphate of lime, etc.,—decomposed by the oxidation of organic matter. The original source of the sulphur is perhaps beyond our reach, but we know that sulphates are constantly present in sea water, and that sulphur exists in organic combination in sea-weeds, these liberating sulphuretted hydrogen sometimes abundantly in their decay. It is not at all uncommon, also, to find concretions of impure carbonate of lime imbedded in bituminous shales. In the Huron shale on the Huron River, at Monroeville, and in the same formation north and east of Columbus, Ohio, such concretions are quite numerous and sometimes large,—eight or ten feet in diameter. They have evidently been slowly formed in place by segregation, and often surround the bones of gigantic fishes (*Dinichthys*), which have served as nuclei for the concretionary action. The lime may have existed as carbonate in solution, or as sulphate which was decomposed by decaying vegetable matter.

Iron is almost omnipresent, under such circumstances usually in the form of carbonate; and the formation of concretions of carbonate of lime and pyrites would naturally follow the mingling of decaying organic matter with sulphate of lime and carbonate of iron.

The decomposition of the pyrites, so abundant in bituminous shales, seems to be the chief source of the chemical action which results in the formation of the mineral springs that issue from these shales in so many localities. The outcrops of the Utica and Hamilton black shales are marked by the emission of sulphur waters, as they are by gas-springs and oil-springs, in New York, Pennsylvania, Ohio, Kentucky, etc.; and it is also true that the great black shales of the Colorado group in the Far West exhibit the same phenomena. Carburetted hydrogen, carbonic acid and sulphuretted hydrogen, are particularly noticeable, as the gaseous emanations from such sources. The solid precipitates include chloride of sodium and various salts of lime, iron, magnesia, etc.

Among the published papers which have reference to the origin of cannel coals and bituminous shales, the following may be consulted :—

On the Formation of Cannel Coal; J. S. Newberry, Amer. Jour. Sci., Vol. XXIII (1857), p. 212.

The Rock Oils of Ohio; J. S. Newberry, Ohio Agric. Report, for 1859.

On the Chemical and Geological History of Bituminous Shales; Dr. T. S. Hunt, Amer. Jour. Sci., Vol. XXXV (1863), p. 157.

The Black Shale; Prof. J. M. Safford, Geol. of Tennessee, 1869, p. 329.

The Huron Shale; J. S. Newberry, Geol. Survey of Ohio, Vol. I, 1863, pp. 107 to 158; Vol. III, 1878, p. 13, etc.

A Source of the Bituminous Matter in the Devonian and Sub-Carboniferous Black Shales of Ohio; Prof. E. Orton, Amer. Jour. Sci., Vol. XXIV (1882), p. 171.

XXII.—*Description of Two New Species of Zonites from Tennessee.*

BY THOMAS BLAND.

Read May 21st, 1883.

Zonites Wheatleyi, nov. sp.

T. umbilicata, depressa, tenuis, nitens, pellucida, fusculo-cornea, delicate striatula; spira sub-planulata; sutura leviter impressa; anfr. 4½, convexiusculis, ultimus basi convexior, ad aperturam rapide accrescens, vix descendens; umbilicus pervius; apertura depressa, oblique lunaris; peristoma simplex, acutum, marginibus approximatis, callo tenui junctis.

Fig. I.

Z. Wheatleyi.

Shell umbilicated, depressed, thin, shining, pellucid, brownish horn-colored, finely striated; spire subplanulate, suture slightly impressed; whorls little convex, the last more convex at the base, rapidly increasing at the aperture, scarcely descending; umbilicus pervious; aperture depressed, obliquely lunate; peristome simple, acute, the margins approximating, joined by a thin callus.

Diam., major 5, min. 3½; Alt., 2 mill.

Habitat.—The Cliffs, Knoxville, Tennessee, Mrs. George Andrews; also, Tiverton, Rhode Island, J. D. Thomson.

Remarks.—This, with the following species, was discovered and communicated to me, in 1879, by Mrs. Andrews, who thus described the locality in which the two species were found:—"The Cliffs rise up 200 feet on the south side of the river,—they are very steep and rocky, face the north, are almost always shady, damp, and covered with mosses and ferns. I collected the shells on the ledges of the rocks among the dead leaves, at an elevation above the river of about 100 feet. I have not found either of the species in any other locality."

Mr. J. H. Thomson, to whom I submitted specimens, sent to me examples of the same species collected by him, "on a high rocky ledge, covered with old trees, at Tiverton, Rhode Island."

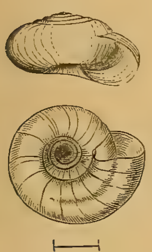
This species, *Z. Wheatleyi*, is more nearly allied to *Z. viridulus*, Mke, than to any other North American form, but differs from it, especially in the form of aperture, in the descending last whorl, and in having a wider umbilicus.

I dedicate the species to the memory of my late valued and lamented friend, Chas. M. Wheatley.

Zonites petrophilus, nov. sp.

T. late umbilicata, depresso-subglobosa, tenuis, nitens, translucens, albida, irregulariter striata ; sutura mediocris ; anfr. 5½—6, convexiusculis, ultimus convexior, non descendens ; umbilicus extus late excavatus, perspectivus ; apertura rotundato-lunaris ; peristoma simplex, paululo subincrassatum, sæpe roseum, margine columellari reflexiusculo.

Fig. II.



Z. petrophilus.

Shell broadly umbilicate, depressed; subglobose, thin, shining, translucent, whitish, irregularly striated ; suture moderately impressed; whorls 5½—6, rather convex, the last more convex, not descending; umbilicus widely excavated externally, pervious ; aperture roundly lunate ; peristome simple, somewhat thickened, often rose-colored, the columellar margin slightly reflected.

Diam., major 6, min. 5,—5¼ ; Alt. fere 3 mill.

Habitat.—The Cliffs, Knoxville, Tennessee, found with *Z. Wheatleyi*, Mrs. Geo. Andrews.

Remarks.—This species is, in general form, nearly allied to *Z. arboreus*, but the color is different, the striæ are more developed, and the umbilicus is much wider.

My friend, Mr. W. G. Binney, examined the dentition of *Z. petrophilus*, and favored me with notes on the subject. He found the teeth 15—1—15, with two perfect laterals, one only on each side. *Z. viridulus* has the same number of laterals, but many more marginals.

I would express my deep obligation to Mrs. Andrews for her uniform kindness and liberality in supplying me, during many years, with numerous rare and interesting species.

Description of Two Species of Land Shells from Porto Rico, W. I.

BY PROFESSOR EDWARD V. MARTENS.

[Communicated by Thomas Bland.]

Read May 21st, 1883.

NOTE BY THOS. BLAND.

In 1882 I forwarded to Prof. v. Martens several shells received long since from my late friend, Mr. Robert Swift, collected, I believe, in Porto Rico, and which I was unable satisfactorily to determine.

I had submitted the shells to Mr. G. W. Tryon, Jr., asking him to compare them with specimens in the Swift Collection, the property of the Academy of Natural Sciences, Philadelphia. Mr. Tryon found no similar forms in the Academy collections, but pointed out the alliance of one of the species with *Chondropoma Tortolense*, Pfr., especially with specimens so labelled, from the island of Anegada:—of this I informed Prof. v. Martens, when presenting the shells to the Berlin Zöological Museum.

In my correspondence with Prof. v. Martens, I mentioned that I was preparing notes on the Geographical Distribution of the Land Shells of the West Indies, with complete lists of the species of each island. He was kind enough to forward to me the descriptions subjoined, for insertion in my proposed paper.

The completion of that paper has, from various causes, been delayed; but I deem it desirable that the publication of the contribution of Prof. v. Martens should be no longer postponed.

Cistula consepta, nov. sp.

Testa ovato-conica, umbilicata, verticaliter confertim tenuiter et inæqualiter lamellata, pallide brunnea, fasciis compluribus rufis ornata ; anfr. 7, priores duo læves, sequentes 4 regulariter crescentes, convexi, sutura profunda, *utrinque prolongationibus lamellarum albis consepta ;* anfractus ultimus in $\frac{1}{4}$ peripheriæ solutus, oblique descendens ; apertura subverticalis, fere ovata ; peristoma duplex, externum late expansum, subundulatum, rufomaculatum, internum distincte porrectum. Operculum paucispirum, oblique radiatim striatum.

Longitudo 13; diam. $8\frac{1}{2}$; aperturæ longitudo, incluso peristomate externo, 6, latitudo $5\frac{1}{2}$; excluso, 4 et $2\frac{1}{2}$ mill.

Porto Rico. R. Swift.

Chondropoma Tortolense, Pfr.

(Mon. Pneum., Suppl. I, p. 142.)

Var. *Major.*

Testa paulum majore, fere unicolore, denticulis suturæ paulo magis prominentibus et magis fasciculatis, peristomatis externi lobo superiore et lobo columellari majoribus, distinctius pliculosis.

Longitudo 18 ; diameter 18 ; aperturæ longitudo, incluso peristomate 7 ; latitudo 6; excluso, 5 et 4 mill.

Porto Rico.

XXIV.—*Apparatus for Rapid Gas-Analysis.*

BY ARTHUR H. ELLIOTT.

Read March 5th, 1883.

In many manufactories and metallurgical works, it is often of great service to be able to make rapid analyses of the gases resulting from various operations, as these analyses serve to control the operations and indicate the progress of the processes. This is especially true for iron and steel works, where a knowledge of the composition of the gases from a furnace is an index of the character of the changes going on inside the furnace. Such rapid analyses are also often needed in gas-works. To meet this requirement of technical works, many methods have been devised and various ingenious forms of apparatus have been constructed. But all the appliances used for this purpose have been based upon the principle of absorbing the various gases in a mixture by liquid reagents. Of the many methods of using liquid reagents, that of Orsat is probably the best known, and the one that has been most used. In this apparatus the gas, after being measured, is made to pass into vessels containing the liquid reagents, and so arranged as to expose a large surface, wet with the reagent, to the mixture of gases. If time is of little value, this apparatus works very well, but it is too slow in its action to be desirable for use in technical works. One great objection to the apparatus itself is the number of stop-cocks attached to the various parts of it. These stop-cocks become incrusted with the various reagents, and refuse to turn without great trouble; and any force applied to them is apt to cause a fracture, which ruins the apparatus for further work until the damage is repaired.

Instead of passing the gas into a vessel containing the chemical reagents, Raoult* put the reagent into a tube containing the

* F. M. RAOULT, *Compt. Rend*, 1876, 844.

gas. In treating a mixture of gases with several reagents, it is necessary to remove one reagent before adding another. This is accomplished by washing out with water in such a manner that the gas is not lost. Raoult performed this treatment of the gases and washing out of reagents, in a graduated tube with two stop-cocks, one at each end; one of the stop-cocks was surmounted with a funnel to introduce the fluids. But the whole affair was not easily managed, and the gases were submitted to an unnecessary amount of washing while removing the excess of reagents used.

Wilkinson modified this method, and devised a very simple and useful apparatus, in which the clumsy manipulations of Raoult were overcome by using a tube with one stop-cock above, the lower end of the tube dipping into water in another tube of much larger diameter. By this means the gases could be treated with liquid reagents, introduced through a funnel attached to the stop-cock above; and by introducing or removing water from the outer tube, the gas could be measured at atmospheric pressure. To facilitate the removal of liquids from the outer tube, the latter has a stop-cock attached below. But, as in the apparatus of Raoult, the gases are submitted to an unnecessary amount of washing when water is introduced to remove the reagents. This washing becomes very important in many cases. For example, take the case of illuminating gas. We introduce potassic hydrate solution to remove the carbonic acid, then potassic pyrogallate to remove oxygen; and now we must wash out the alkali before adding bromine to absorb the illuminants. To do this, much water is needed, and this large quantity of water will wash out some of the illuminats, often as much as two per cent. n/

To overcome this difficulty of excessive washing, I have devised the apparatus which is the subject of this paper. In this process, the gas is removed from the absorbent liquid and measured in another vessel, without washing.

The apparatus is shown in Plate XXII. The tube *A* is of about 125 *c.c.* capacity, whilst *B*, although the same length, holds only 100 *c.c.* from the point *D*, or zero, to the mark on the capillary tube at *C*, and is carefully graduated in $\frac{1}{10}$ *c. c.*

The attachments to these tubes below are seen from the drawing, except that the stop-cock *I* is three-way and has a delivery through its stem. The bottles *K* and *L* hold about a pint each. The tubes *A* and *B* are connected above with one another, and also with the cylindrical funnel *M*, by a series of capillary tubes about one millimeter in diameter inside. There is a stop-cock at *G* and another at *F*, while the funnel *M*, which holds about 60 *c.c.*, is ground to fit over the end of *F* above. At *F* is a piece of rubber tubing uniting the ends of the capillary tubes, which are filed square to make them fit as closely as possible.*

In beginning the analysis of a mixture of gases, the stem exit of the three-way cock *I* is closed by turning it so that *L* and *A* are connected through the rubber tubing; the stop-cocks *F* and *G* are opened, and water is allowed to fill the apparatus from the bottles *K* and *L*, which have been previously supplied.

When the water rises in the funnel *M*, and all air-bubbles have been driven out of the tubes, the stop-cocks *F* and *G* are closed, the funnel *M* removed, and the tube delivering the gas attached in its place.† By now lowering the bottle *L* slowly, and simultaneously opening the stop-cock *F*, the tube *A* is nearly filled with gas, and the stop-cock *F* is closed. The tube delivering the gas is removed, the funnel *M* replaced, the bottle *L* raised, the bottle *K* lowered, and by opening the stop-cock *G*, the gas is transferred to the graduated tube *B*.

The bottle *K* is now adjusted so that the level of the water in it is the same hight as the zero-mark *D* on the graduated tube. By means of the bottle *L*, the gas is adjusted to the zero-mark *D* in the graduated tube, and the stop-cock *G* is closed.

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* The hight of the apparatus can be diminished by having bulbs at the points of union of the capillary tubes and the absorption and measuring tubes *A* and *B*; such bulbs being of about 25 cubic centimetres capacity, and the graduations continued downwards from the bulb on the tube *B*. Making the funnel spherical also reduces the hight of the apparatus.

† A tube of the same construction as is shown in the explosion-burette figure can be attached to the end of the stop-cock, and thus facilitate the attachment of the rubber tubing. See H, Plate XXIII.

The excess of gas in *A* is expelled by opening the stop cock *F* and raising the bottle *L*. The gas remaining in the capillary tube between *C* and the vertical part is disregarded, or its value may be ascertained and an allowance made ; but usually it is too trifling to be worth notice.

Having measured the gas, it is now transferred by means of the bottles *K* and *L* into the tube *A*, and the fluid chemicals added by placing them in the funnel *M* and allowing them to flow down the sides of the tube *A* slowly, care being taken *never* to let the fluids run below the level of the top of the vertical tube in the funnel. It is best to have a mark on the outside of the funnel at least three-fourths of an inch above the top of the level of the vertical tube, and never to draw the fluid down below this point.

Having treated the gas with the chemical, it is transferred by means of the bottles to the tube *B*, to be measured. If the chemical gets into the horizontal capillary tube, the passage of a little water from the bottle *K* will remove it, before transferring the gas. When the gas residue is in *B*, and the fluid of *A* has been adjusted at the mark *C* on the horizontal tube, the stop-cock *G* is closed, the bottle *K* is lowered till the level of liquid in it and in the tube *B* are the same, and the reading is then made. The tube *A* is now filled with the chemical just used as absorbent, and water; by turning the stem of the three-way cock *I*, so that it communicates with *A*, and is open below, and by also opening the stop-cock *F*, the contents of the tube can be run out, and water added through the funnel *M* to clean the tube for a new absorption. When the tube is clean, by turning the stop-cock *I*, so that *A* and *L* are connected, the water is forced into *A*, and the whole is ready to receive the gas in *B* for new treatment.

In using the apparatus, the chemicals are added in the following order :—

1. Potassic Hydrate (1 in 20) to absorb carbonic acid. If illuminating gas is under examination, a very little of the reagent will be necessary, and it is better to use a solution of potassic hydrate of four times the above strength, in order to prevent

washing out of the illuminants. For traces of carbonic acid, and also for the determination of sulphurous acid and sulphuretted hydrogen, special methods are necessary.

2. Bromine, to absorb illuminants. This is added to some water placed in the funnel. It is best handled with a very small pipette, since only a few drops are necessary. Add it till the tube is filled with its vapor; then absorb the vapor with potassic hydrate used for carbonic acid.

3. Potassic Pyrogallate, to absorb oxygen. Solution of potassic hydrate (1 in 8), containing about three per cent. of pyrogallic acid.

4. Cuprous Chloride, to absorb carbonic oxide. This is a solution (1 in 4) in concentrated hydrochloric acid. After using it, and *before* transferring the gas to the measuring-tube, a little water is added to absorb the acid vapors.

By this method, a mixture containing carbonic acid, oxygen, illuminants and carbonic oxide, can be analyzed in from twenty to thirty minutes, according to the amount of practice the operator has had with the apparatus.

Compared with Orsat's process, the work can be done with the above-described apparatus in one-fourth the amount of time, and with identical results.

The water used in the apparatus should have the same temperature as the room in which the analysis is made; and by careful handling, little or none of the chemicals get into the bottle *L*. When working in a warm place, the tube *B* should be surrounded with a water-jacket to prevent change of volume in the gas while under treatment. *

Having added the above absorbents, the residue of gas may consist of hydrogen, marsh-gas, and nitrogen; and for the determination of these, I have devised a simple form of explosion-burette, shown in Plate XXIII. It consists of a burette, *D*, of

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* Whenever possible, it is better to collect the gas in tubes and transfer it to the apparatus in a position away from sources of heat.

heavy glass, graduated in tenths of cubic centimetres, and holding one hundred cubic centimetres to within about two inches of the lateral tube, *E*, below; the upper end is closed by a stop-cock, *B*, over which fits a funnel, *A*, in the same manner as in the apparatus described above. The graduations on the tube are made so that the stop-cock is the zero point, and the 100 mark is below, near the lateral tube, *E*.

Into the upper end of the burette, at *C*, are fused two platinum wires for an ignition-spark. At the lower end of the burette, the glass is drawn out to receive, at *F*, a piece of soft rubber tubing about three feet long, which in turn communicates with the aspirator bottle, *G*. Care should be taken that the opening of *F* and the tubulature of the bottle, *G*, are not smaller than the bore of the rubber tubing used to connect them, since any contraction would prevent the cushioning of the explosion when the spark is passed.* The bent piece, *H*, is ground to fit over the stop-cock, *B*, when the funnel, *A*, is removed, and facilitates the transfer of the gases from the absorption-burette before described, as it is easier to slip a piece of rubber tubing over the smooth end of *H* than over the ground end of the stop-cock, *B*. The stop-cock, and also the fitting, *H*, have capillary tubing of about one millimetre bore. The stop-cock at *F*, and its tube attaching it to the burette, are of ordinary size, about one-eighth to three-sixteenths of an inch.

The operation of the burette is as follows :—

The funnel is removed from the absorption-burette of the previously described apparatus, and a fitting exactly like *H* is substituted for it. The gas should be previously transferred to the measuring-tube of the absorption-apparatus. The explosion-burette is placed in a vertical position in a stand near the absorption-apparatus. The bent tube on the upper stop-cock of

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* It is also most important that the clamp holding the burette should not hold too tightly, as pressure upon the glass will cause a fracture on exploding the gases. It is better to use a spring clamp.

the absorption-apparatus is now attached to a piece of rubber tubing long enough to reach to the corresponding bent tube of the explosion-burette. The aspirator-bottle, *G*, is filled with water, and by raising it and opening the stop-cock, *B*, and closing *E*, the explosion-burette is filled with water, including the bent tube, *H*, fitted over the end of the stop-cock, *B*. By a similar movement of the aspirator-bottle attached to the absorbtion-apparatus, the corresponding bent tube and its rubber tube are also filled with water. Care should be taken that the water completely expels all air-bubbles from the capillary tubes and the rubber tube. The explosion-burette is now attached to the absorption-burette by means of the rubber tubing already filled with water, by slipping this rubber tubing over the bent tube of the explosion-burette; taking care to exclude all air-bubbles when making the attachment. To facilitate the connecting of the bent tubes and the rubber tubing, the ends of these tubes should be drawn out so that the rubber tubing will easily slip over them.

Having connected the explosion-burette with the absorption-apparatus in the manner described above, we are now ready to transfer the gas-mixture for the explosion. For this purpose, the three-way cock of the absorption-apparatus is turned so that the bottom of the absorption-tube is closed. By now opening the stop-cocks above on the absorption-apparatus, and also on the explosion-burette, and by moving the aspirator-bottles, any desired quantity of gas can be transferred from the absorption apparatus to the explosion-burette. When the proper quantity (about eighteen or twenty cubic centimetres is sufficient) of gas has been transferred, the stop-cocks of the absorption-apparatus are closed, also the stop-cock of the explosion-burette. By means of the aspirator-bottle, *G*, the level of the water is adjusted so that the gas is at atmospheric pressure, by bringing the level of the water in the aspirator-bottle to the same hight as that in the explosion-burette. This gives the correct reading of the quantity of gas used. We now have to mix this gas with the proper quantity of oxygen to cause an explosion on passing a spark through the wires, *C*. This oxygen is admitted through the stop cock, *E*,—most conveniently from a gas-holder or cylin-

der under pressure. Having added the proper quantity of oxygen (about equal in volume to the gas used),* the correct volume of the mixture thus obtained is read off in the same manner as that of the original gas. But before the final reading is made, the burette is removed from the stand, and by a few movements from vertical to horizontal positions, the gases are mixed, and any oxygen that collects in the tube, *E*, is removed to the bulk of the gases in the upper part of the burette. Having taken the final reading of the mixture, the upper part of the tube is tapped slightly to dislodge any water adhering to the platinum wires, and the spark from an induction coil is passed between them, the aspirator-bottle being below the level of *F*, in order to expand the mixture. A sharp click is now heard, and the tube is allowed to stand so that the heat of the explosion may pass away before reading the contraction. When the tube is cool, the reading is taken by lifting the aspirator-bottle as before. This reading gives the contraction, and by removing the bent tube and replacing the cylindrical funnel, *A*, the carbonic acid resulting from the explosion may be absorbed with potassic hydrate, as in the absorption-apparatus, the readings always being taken after adjusting the levels of the liquids in the burette and the aspirator-bottle.

When removing the bent tube and attaching the cylindrical funnel, care should be taken that the air in the capillary tube of the stop cock is removed. This is accomplished by attaching the funnel, putting into it a little potash solution, and then inserting a piece of thin copper wire into the capillary tube of the stop-cock; by this means the air-bubbles are readily removed. Like the absorption-apparatus previously described, this explosion-burette is intended for rapid work where some accuracy is sacrificed to the saving of time. It has the great advantage that the explosion can be made over water—the long piece of rubber tubing acting as a cushion to the shock. I have used this burette for over a year, and with the most satisfactory results.

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* If the gas mixture contains little or no nitrogen, it is better to add half the volume of oxygen and one volume of atmospheric air, to moderate the force of the explosion.

It is only intended to be used with mixtures of gases, containing hydrogen, marsh-gas, and nitrogen,—the other ordinary constituents being determined in the absorption-apparatus.

The following formulas are used in calculating the results of the explosion of a mixture of hydrogen, marsh-gas and nitrogen, or hydrogen and nitrogen.

Let C = Contraction. D = Carbonic Acid : then,—

$$\frac{2\,C - 4\,D}{3} = \text{Hydrogen.}$$

and D = Marsh-gas.

In the case of hydrogen and nitrogen the above formula becomes simply

$$\frac{2\,C}{3} = \text{Hydrogen.}$$

These calculations give the quantities of the above gases found in the number of cubic centimetres of gas-residue used in the explosion; it is of course necessary to calculate these upon the total amount of residue left in the absorption-burette. The nitrogen is found by adding together the figures for the other constituents of the gas and subtracting their sum from one hundred.

The subjoined table illustrates the character of the mixtures of gases that can be analyzed with the above-described apparatus.

Carbonic Acid	3.4	7.3	0.0	0.7
Illuminants	—	—	6.3	15.6
Oxygen	0.0	1.0	.3	1.5
Carbonic Oxide	40.2	29.8	6.0	8.5
Hydrogen	44.9	55.8	—	13.0
Marsh-gas	——	0.0	—	33.8
Nitrogen	11.50	6.1	—	26.9

With care, and a little practice with the apparatus, results are obtained within a few tenths of a per cent. of the truth, and this at an immense saving of time over the older methods of analysis —the results answering every ordinary purpose in gas and metallurgical works. After some practice, a complete gas-analysis, using the absorption-apparatus and explosion-burette, can be made in less than an hour.

School of Mines, New York, 1883.

XXV.—*Descriptions of New Species of Birds of the Genera Chrysotis, Formicivora and Spermophila.*

BY GEORGE N. LAWRENCE.

Read May 28th, 1883.

1. Chrysotis canifrons.

The general coloring is green, the abdomen washed with bluish, the feathers of the hind neck edged with black, and those of the throat mixed with yellow ; the front, the chin, and the upper part of the throat, are grayish ash ; this color is bordered on the crown with dull pale yellow ; sides of the head dull yellow ; the primaries are deep blue, with a speculum of bright scarlet ; the bend of the wing is clear yellow, marked with scarlet next the body ; thighs gray ; tail-feathers green, ending rather broadly with light greenish yellow ; the basal portions of the feathers are yellow for half their length, and are marked with red ; the outer feather is bluish on the outer web ; bill whitish horn-color, with the tip dusky ; feet dark gray.

Dimensions approximately ; length, 14 inches ; wing, 9 ; tail, 6.

Habitat, Island of Aruba, West Indies.

Remarks.—The above-described parrot was brought alive, by our associate, Dr. A. A. Julien, in the spring of 1882, when he returned from the islands of Curaçao, Buen Ayre and Aruba. He obtained it at Aruba, and thinks it occurs in abundance on Buen Ayre (no specimens, however, were procured there), but is not found on Curaçao.

I saw this parrot soon after his return, and took notes of its plumage, and also of its dimensions, as well as I could from a living bird, though it was very gentle. I considered it an undescribed species, but deferred publishing an account of it, for the sake of a further examination, and to see if any change would take place in its plumage, especially in the ashy coloring

of the front and chin, though I thought it to be fully adult. It was left in charge of a bird-dealer in Brooklyn, L. I., from whom I exacted the promise, that in case of its death he would take it to Mr. John Akhurst, to whom I had given directions to preserve the skin. Unfortunately, it died during the summer, but the skin was not saved.

Therefore, I have had to rely on my notes, which I was pleased to find gave quite a satisfactory account of its plumage.

The most marked difference from its allies seems to be, the ashy front and chin, and these the dealer assured me did not change at all in coloring while it lived.

2. Formicivora griseigula.

The upper plumage is of a deep, rather bright, ferruginous; the front, lores and crown are brownish; the tail-feathers are dull black, crossed with waving bars of very pale dull ferruginous; these bars are of about half the width of the black interspaces, and are eleven in number; the quills are dark liver-brown; their edges and the wing coverts are rufous, like the back; the inner edges of the quills are of a very pale salmon-color; the sides of the head are blackish; the shafts of the ear-coverts are white; the chin and throat are dark gray, a little lighter in color on the former; the breast, abdomen and under tail-coverts are of a light dull rufous; the bill and feet black.

Length (skin), $5\frac{1}{2}$ inches; wing, $2\frac{3}{8}$; tail, $2\frac{3}{8}$; tarsus, $\frac{7}{8}$; bill, $\frac{1}{2}$.

Habitat, British Guiana. Type in my collection.

Remarks.—By its general dark coloration, gray throat and barred tail, this bird is readily distinguished from all others of the genus.

3. Spermophila parva.

Female. Upper plumage of a light, warm, earthy-brown, a little deeper in color on the crown, and brighter under and behind the eyes; the throat is grayish-white; rest of the under parts of a very light shade of brown, whitish on the middle of the abdomen; the smaller and middle wing-coverts are dark brown, the latter ending with whitish; the larger coverts are also dark brown and margined with whitish; quills dark umber-brown; the outer tertials edged with light fulvous, the inner with whitish; tail, umber-

brown, ending with dull white; "iris brown; bill light-brownish; feet dark grayish-ash."

Length (skin), $3\frac{5}{8}$ inches; wing, 2; tail, $1\frac{5}{8}$; tarsus, $\frac{1}{2}$.

Habitat, Mexico, Tehuantepec City. Type in National Museum, Washington.

Remarks.—I have had this specimen for several years, and have delayed its description, hoping to get the male. It was obtained by Prof. Sumichrast, to whom I wrote requesting him to try to procure the male. As he left that part of Mexico, and is now deceased, I have thought best to describe it. It somewhat resembles the female of *S. minuta,* but is distinguished from it by the smaller size, lighter color and whitish throat, and by having the wing-coverts, tertials and tail-feathers edged with whitish; the bill is not half the size of that of *S. minuta.*

May 25th, 1883.

XXVI.—*Observations of the Transit of Venus, December* 6. 1882.

BY J. K. REES,

Director of the Observatory of Columbia College, N. Y. City.

Read December 11, 1882.

The station occupied was the roof of the unfinished Observatory of Columbia College, where the telescope was placed at the southwest corner. This roof is extraordinarily strong and solid. The beams are of iron, 12 inches in depth; and solid brick arches spring from beam to beam. The hight of the roof from the street is about 110 feet, and the walls supporting it are four feet thick. An unobstructed view was had of the whole transit.

The position of the instrument was a few feet only from the centre of the old Observatory; so that we may take the longitude and latitude of our instrument from the American Ephemeris.

Latitude, $+ 40° 45' 23''.1$.

Reduction to Geocentric Lat., $-11' 22''.7$.

Log. $\rho = 9.999384$.

Longitude—

		h.	*m.*	*s.*
From Washington,	—	0	12	18.40.
		h.	*m.*	*s.*
From Greenwich,	+	4	55	53.69.

The time-pieces used were a mean-time chronometer, No. 1853, made by Parkinson & Frodsham, of London, England, and a sidereal chronometer, No. 1564, made by Negus & Co., of New York City.

The instrument used in the observations was an equatorially mounted refractor, made by Alvan Clark & Sons. Aperture, 5.09 inches; focal length of object-glass, 74.3 inches. The magnifying powers used were 48 on first contact; 165 on second and third contacts; 95 on fourth contact.

The telescope was moved by clock-work, and was similar in all respects to the instruments made for the transit of Venus expeditions of 1874.

In making chronometer comparisons, the sidereal chronometer was left at the College, and the mean-time chronometer was carried to the instruments on which signals were to be received.

CHRONOMETER COMPARISONS.

December 5th, P. M., at the College.

Negus, Sidereal.				P. & F. Mean-Time.		
h.	*m.*	*s.*		*h.*	*m.*	*s.*
21	39	14.0	=	4	26	15.0
21	42	4.5	=	4	29	5.0

December 5th, P. M., at 42d Street Depot.

West'n Union Time Signals in N. Y. City Hall time.				Mean-Time Chronometer. P. & F.		
4	41	0.0	=	4	43	2.0
4	42	0.0	=	4	44	2.1
4	43	0.0	=	4	45	2.0
4	44	0.0	=	4	46	2.0
4	45	0.0	=	4	47	2.0

December 5th, P. M., at the College.

Negus, Sidereal.				P. & F. Mean-Time.		
22	20	27.5	=	5	7	25.0
22	23	18.0	=	5	10	15.0
22	26	30.0	=	5	13	26.5

December 5th, P. M., at the College.

Negus, Sidereal.				P. & F. Mean-Time.		
1	54	10.0	=	8	40	32.0
2	0	9.0	=	8	46	30.0

December 6th, A. M., at the College.

Negus, Sidereal.				P. & F. Mean-Time.		
13	23	42.5	=	8	8	10.0
13	29	33.5	=	8	14	0.0

At Western Union Building, Broadway and Liberty Street: Reception of the Washington Time-Signals.

P. & F., Mean-Time Chronometer.						Washington Signals.		
		lost	=	30 sec.	=	11	56	30.0
12	11	14.0	=	min.	=	11	57	0.0
12	11	44.0	=	30 sec.	=	11	57	30.0
12	12	lost	=	min.	=	11	58	0.0
12	12	44.0	=	30 sec.	=	11	58	30.0
12	13	14.0	=	min.	=	11	59	0.0
12	13	44.0	=	30 sec.	=	11	59	30.0
12	14	14.0	=	min.	=	12	0	0.0

December 6th, P. M., at the College:

Negus, Sidereal.				P. & F. Mean-Time.		
18	18	46.5	=	1	2	25.0
18	21	22.0	=	1	5	0.0
18	24	12.5	=	1	7	50.0

December 7th, A. M., at the College:

Negus, Sidereal.				P. & F. Mean-Time.		
16	9	54.5	=	10	49	55.0
16	12	50.0	=	10	52	50.0
16	21	56.5	=	11	1	55.0

December 7th, A. M., at Western Union Building.

Western Union Time Signals in N. Y. City Hall time.				P. & F. Mean-Time.		
11	50	0.0	=	11	52	1.7
11	51	0.0	=	11	53	1.6
11	53	0.0	=	11	55	1.8

Last comparison by Mr. Hamblet.

December 7th, P. M., at Western Union Building.
Reception of the Washington Time-Signals.

P. & F., M. T. Chronometer.						Washington Signals.		
		lost	=	30 sec.	=	11	56	30.0
		lost	=	min.	=	11	57	0.0
		lost	=	30 sec.	=	11	57	30.0
12	12	13.7	=	min.	=	11	58	0.0
		lost	=	30 sec.	=	11	58	30.0
		lost	=	min.	=	11	59	0.0
12	13	43.6	=	30 sec.	=	11	59	30.0
12	14	13.6	=	min.	=	12	0	0.0

December 7th, P. M., at the College:

Negus, Sidereal.				P. & F., Mean-Time.		
19	14	25.0	=	1	53	55.0
19	20	6.0	=	1	59	35.0

The Western Union time-signals sound the local time of the New York City Hall. The assumed longitude of the City Hall from Washington is — 12m. 10.47s.

Mr. Hamblet, in charge of the system, gives the errors of his clock and signals as follows:—

December 5th,	N. Y. City Hall,	noon,	1.11	sec. fast.
" 6th,	"	"	1.35	"
" 7th,	"	"	1.41	"

Prof. Wm. Harkness, of the Executive Committee of the Transit of Venus Commission, has kindly furnished me with the corrections to the Washington clock-signals, as follows:—

December 4th,	correction	=	—	0.24 sec.
" 5th,	"	=	—	0.47 sec.
" 6th,	"	=	—	0.22 sec.
" 7th,	"	=	—	0.68 sec.

These corrections refer the time to the centre of the old dome, from which all longitudes are counted.

PHENOMENA.	P. & F. Chr. M. T. Un-corrected.	Col. Coll. M. T. Corrected.*	REMARKS.
	h. m. s.	h. m. s.	
Faint clouds before the Sun	9 9 30	9 7 35	
Notch plainly on, . . .	9 10 44	9 8 49	I. Contact. Mag. power, 48. Est. 1m. late.
Light thro' Venus's atmosphere, ...	9 23 55	9 22 0	
Ditto, beautifully seen, .	9 26 15	9 24 20	
Not yet.	9 29 54	9 27 59	
On (no "drop")	9 30 41	9 28 46	II. Contact. Mag. power, 165. Good obs.
Clearly on, ...	9 31 1	9 29 6	
Preceding limb of Venus quite dark	2 50 28	2 48 33	A very peculiar phenomenon.
Black border at preceding limb extends to following limb, ...	2 53 21	2 51 26	
Faint show of "drop," .	2 53 56	2 52 1	
Tangency, ...	2 54 9	2 52 14	III. Contact. Mag. power, 165. Good obs.
Not yet, ...	3 13 19	3 11 24	
Off, ...	3 13 47	3 11 52	IV. Contact. Mag. power, 95. Poor seeing.

The first three contacts were observed with a Pickering solar eye-piece and a light yellow shade-glass. The last contact was observed with a reflecting wedge.

Reducing the contacts to Washington Mean Time, we have:

I	Contact	8	56	30.6	Est. 1 min. late.
II	"	9	16	27.6	Good observation.
III	"	2	39	55.6	Good observation.
IV	"	2	59	33.6	Poor seeing.

Remarks on Phenomena Observed.

I estimated the 1st contact observation as over a minute late. The light shining through Venus's atmosphere was a fine

* NOTE.—The time-corrections as determined from the Washington Signals are used.

sight. I should say that it first appeared to my eye when the planet was a little more than half-way on the sun, and disappeared about a minute before the planet reached 2d contact. This line of light, marking out the portion of Venus's disk not on the sun, changed its appearance considerably while my attention was fixed upon it.

I first saw a faint arc of light marking out only a few degrees of the disc not on, and farthest from, the sun. A little later, a fine semi-circular line of gold was seen; and finally, this line broadened near the sun, and could not be seen farther out, giving the appearance of two wings of light.

In the second case, the line of light appeared to be the continuation of the dark rim of the planet.

In the third case, the bases of the wings resting on the sun were plainly out of the line of the dark circumference. I watched for the repetition of these appearances between the 2d and 4th contacts, but failed to see anything.

The sky between the 1st and 2d contacts was much clearer of haze than between the 3d and 4th.

At 2d contact, I saw no indication of the "black drop." The tangency of Venus's disk and that of the sun was well seen. During the passage of Venus over the sun's face, I observed her disk with magnifying powers, as follows:—48—95—165—385—but saw no indications of an atmosphere.

The disk of Venus did not appear to be uniform in blackness, but to be spotted with grayish or whitish matter, reminding one of patches of snow. This was seen under the different magnifying powers used. When Venus neared the 3d contact, a very peculiar phenomenon was observed. The preceding limb of Venus was seen to be darker than the central portion. Later, the edge of the planet became of a bluish-black color around to the following limb.

The phenomena connected with this were very distinct. When the planet was near 3d contact, a faint "black drop" was observed for a brief time. It disappeared very shortly, and

the 3d contact was finely seen. The 4th contact was interfered with by the haze and clouds.

For assistance during the transit, I am much indebted to the civil-engineering students of the class of '83, School of Mines.

NOTE 1.—The contact-times (corrected) differ slightly from the times given in the "Transactions," owing to data lately received in regard to the Washington time-signals.

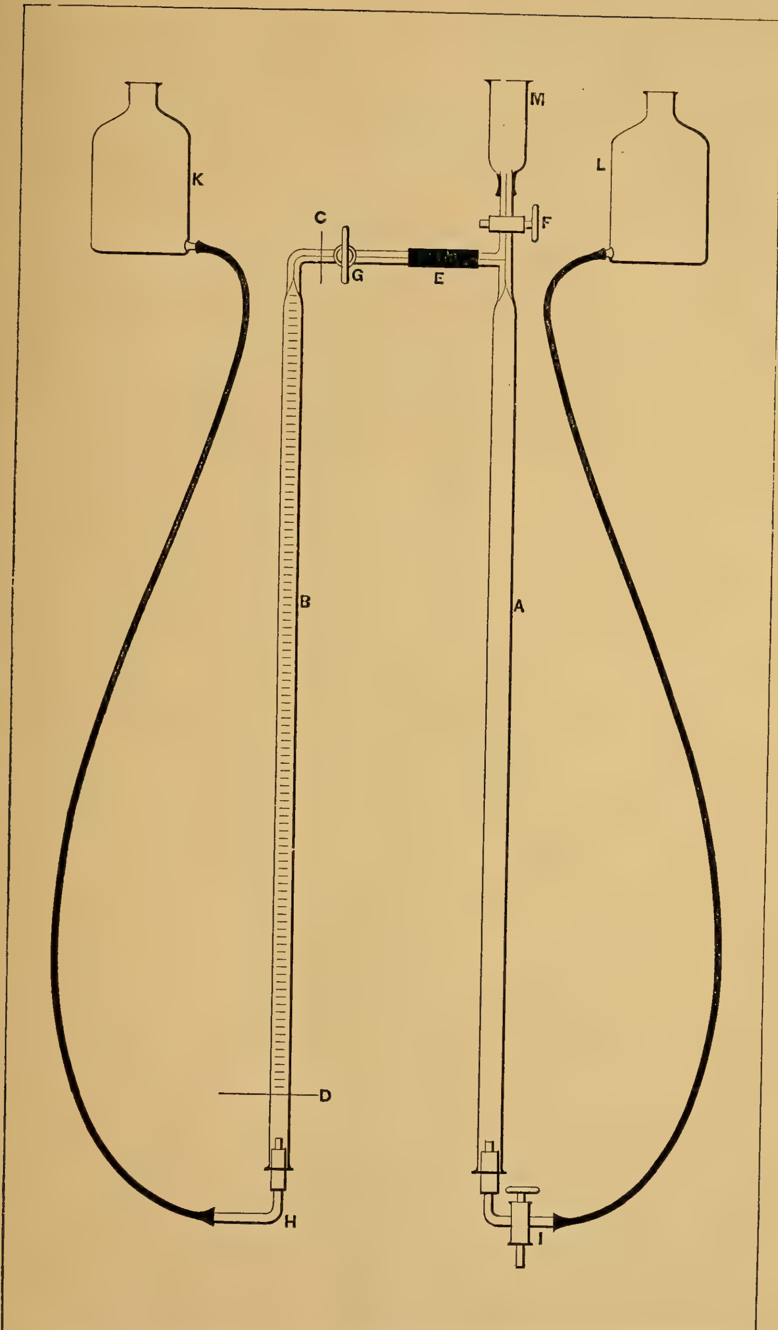
NOTE 2.—The peculiar marking on Venus's disc, when near 3d contact, reminds me of the drawings of the markings on Jupiter's fourth satellite, only there we have the light border on dark ground. (See Webb's "*Celestial Objects*," p. 168, 4th edition.)

J. K. R.

ADDENDUM.

I have received the following data from an amateur observer in this city, Judge Addison Brown, 233 East 48th Street.

CONTACTS.		OBSERVED TIME.			CORRECTED.					
		h.	*m.*	*s.*	*h.*	*m.*	*s.*			
I,		9	11	21	9	8	38			
II,	not yet,	9	31	40	9	28	57	9	29	2
	past,	9	31	50	9	29	7			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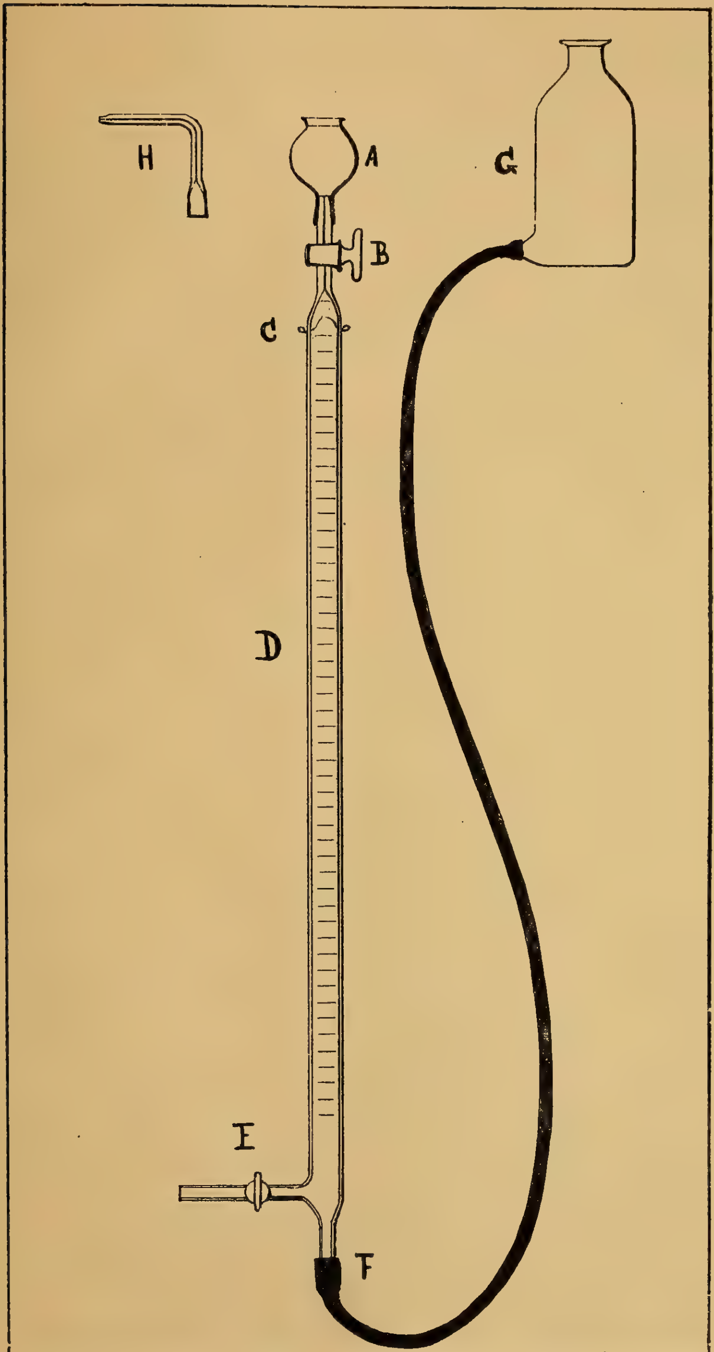
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GENERAL INDEX.

For all names in Botany and Zoölogy, see Index of Nomenclature, following the General Index.

For full titles of papers in this volume, and names of their authors, see Table of Contents.

For references to apparatus, discussions, experiments, processes, and theories, on the following and kindred subjects connected with electrolysis, see Article XIX, Index to the Literature of Electrolysis, pages 313 to 349.

Alloys.
Amalgams.
Arborization of metals.
Electro-chemistry.
Electrolysis of various substances.
Electro-metallurgy.
Electro-plating.
Electro-typing.
Metallic precipitation.
Ozone.
Photo-galvanic processes.

ADDENDA TO INDEX.

INDEX TO NOMENCLATURE.

[The names of *new* species are printed in Roman letters; synonyms and species to which reference is made are in *Italics;* names of sub-families, families, or higher divisions, in SMALL CAPITALS.]

ERRATA.

Page 103, line 19 from the top, for ot read to.

Page 237, line 20 from the top, for *Hesingeri* read *Hisingeri*.

Page 285, line 15 from the top, for Beckham read Peckham.

Page 288, line 4 from the top, for Furnarius read Formicarius.

Page 333, under 1857, first column, for Geuthier read Geuther.

Page 336, under 1861, first column, for Plauté read Planté.

Page 341, line 7 from the top, for Anz. Ann. Chim. read A. c. p.

Page 349, line 22 from the top, for Wein. read Wien.

Page 357, line 5 from the foot, for Protocardia read Lunulicardium.

Page 373, line 10 from the foot, for illuminates read illuminants.

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VOLUME II, 1880—82.

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